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List of abbreviation

AOR	Adjusted Odds Ratio
AUC	Area Under Curve
BMI	Body Mass Index
CI	Confidence Interval
DHS	Demographic Health Survey
DNA	Deoxyribonucleic Acid
EA	Enumeration Area
GSHS	Global School Health Survey
LGA	Local Government Area
NHANES	National Health and Nutrition Examination Survey
ROC	Receiver Operating Characteristics
TSKFT	Triceps Skinfold Thickness
WC	Waist Circumference
WHO	World Health Organisation

Abstract

Background Obesity is a global public health problem. Data on the epidemiology of obesity in many sub-Saharan African countries including Nigeria is scant. The objectives of this study were to determine the prevalence of obesity, the associated sociodemographic and behavioural factors, as well as the impact of perceptions of large body size, on obesity and overweight, in Enugu Nigeria.

Method A cross-sectional household survey of adults aged 20-60 years, was conducted using multi-stage cluster randomised sampling. This was preceded by a pilot study involving 79 adults and 29 households. Government-defined population census enumeration areas with definite geographic boundaries served as clusters. Anthropometric measurements were taken using standard methods. All prevalence estimates were population-weighted. Analyses were done at the 95% confidence level.

Results Data from 6628 individuals from 2843 households were analysed. The overall population-weighted prevalence of obesity, overweight, normal weight and underweight are 6.8%, 19.0%, 65.1% and 9.1% respectively. Female gender, urban residents, adults older than 40 years of age, and high-income earners are more likely to be obese than their corresponding counterparts. Nearly 45% of the population perceive obesity as a desirable attribute. More than 50% of the population misperceive their body sizes. Positive perception of large body size is a significant predictor of obesity. Dietary factors do not have significant independent impacts on obesity. A third of the population is physically inactive.

Conclusion: The prevalence of obesity and overweight in Enugu Nigeria is high, with the burden of obesity fast approaching that of underweight. Female gender, urban dwellers, older adults and high-income earners are at higher risk for obesity and overweight. There is a high level of veneration of large body sizes and physical inactivity, which contributes to the high population burden of obesity and overweight. Important policy recommendations are made.

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CHAPTER 1

1. Introduction

1.1. Global overview of obesity

Obesity is a preventable condition with several adverse health implications. The global burden of obesity is reported to have reached pandemic proportions, and it is seen as one of the most crucial public health problems in contemporary times. In the year 2000, the World Health Organisation (WHO), warned of the rising global burden of obesity[2]. The prevalence of obesity has risen more rapidly than expected and even involving low-income countries that were least expected to have obesity as a public health problem[3]. A considerable proportion of the world's adult population (about 13%) is estimated to be suffering from obesity[4]. The WHO reports that this figure is more than 15 times the world's adult population living with the human immunodeficiency virus (HIV) in 2016[5].

The clinical importance of obesity lies in its association with numerous non-communicable diseases with huge morbidity and mortality burden. An estimated 2.8 million deaths across the globe annually, are traceable to illnesses that have obesity and overweight as major modifiable risk factors[6]. These include diabetes, hypertension, coronary artery diseases, stroke, cancers (endometrial, breast, colon cancers), polycystic ovary diseases, gallbladder diseases, osteoarthritis, and obstructive sleep apnea[7]. A wide range of adverse surgical and obstetric outcomes are also associated with obesity. Reports from high-income countries indicate that a variety of emotional and psychological disturbances are also associated with obesity. It is reported to predispose people to personal feelings of loss of self-esteem, resulting from prejudice and discrimination at work, school and social situations[8, 9]. The problem of obesity imposes substantial economic costs to the individual, the nation and the health system.

Obesity has been known to represent a state of an excess proportion of total body fat. However, it is known that the aetiology of obesity is much more complicated than simple energy imbalance. Evidence suggest that obesity represents a complex interplay between genetic, environmental, psychological and socioeconomic factors. These include metabolic, genetic, endocrine, ethnic, racial, cultural, dietary, psychological, environmental and economic factors[7, 10, 11]. Sex, age and level of activity are also etiological variables in the obesity equation. Obesity is more prevalent in women than men globally. This is expected owing to the biologically higher percentage of body fat in women than in men[7]. Although a disease of all races and ethnicity, some racial and ethnic groups are reported to be particularly predisposed. These include African Americans, Hispanics, Pacific Islanders, the Pima Indians of Arizona, Asian-African immigrants in Israel[7, 12].

In Nigeria, obesity is culturally and socially acceptable and not usually recognised as a medical problem[13]. Anecdotal evidence shows that obesity is viewed as a sign of wealth and power in many parts of Nigeria, especially the southeastern region. In some cultures in southern Nigeria, prospective brides are kept in 'fattening' rooms for months to make them fat enough and more appealing to their prospective grooms [14, 15]. It is noteworthy that Pacific Islanders, who have the highest global rate of obesity, also associate fatness with power, beauty and affluence[16].

A good understanding of the epidemiology is needed to tackle the scourge of obesity and overweight. Little is known about the epidemiology of obesity in sub-Saharan Africa. The objective of the research project is to determine the prevalence and associated risk factors for obesity in Enugu southeast Nigeria. Enugu state has a total population of 3.3 million people out of which the adult population of interest (20 – 70 years of age) is 1.63 million[17]. The research project is a household survey of 6, 665 individuals, that is representative of the adult population of Enugu state of Nigeria. The sampling method was multi-stage cluster randomised. The state was divided into urban and rural strata. To get a representative sample, the urban stratum was further divided into sub-strata namely upper class, middle class, lower class and university community. Government delineated population enumeration areas (EA) with definite geographical boundaries, and an average population of 215 persons per EA were used as clusters for the study. Selection of the clusters was made in reverse proportion to actual the population size, that is 70% were selected from the urban strata and 30% from the rural strata. The number of clusters per urban sub-strata were allocated proportionally to projected population. For the rural strata, one cluster was allocated to each selected local government area (LGA). The main survey was preceded by a pilot survey involving 79 adults and 29 households in non-participating EAs to evaluate the feasibility of the study and identify potential challenges with the field data collection. Field data collection for the main study started in July 2015 and ended in May 2016. The main outcomes were the prevalence of obesity and overweight in a state-wide representative population sample, the socio-economic, and psychological risk factors associated with obesity and overweight, people's perception of body size and its correlation with obesity in a state-wide representative sample of Enugu state population.

CHAPTER 2

2. Literature Review

2.1. Definition, Measurement and Classifications of Obesity

The World Health Organisation defines obesity and overweight as "abnormal or excessive fat accumulation that presents a risk to health"[4]. Body fat is made up of essential body fat and storage body fat. Essential body fat is necessary for the maintenance of life and reproduction; hence women have more essential body fat than men (10-13% versus 2.5%). Storage fat is made of fats that accumulate in adipose tissues of the body. BMI is obtained by dividing the weight of the individual in kilograms by the square of the height in meters. A BMI of 30 kg/m^2 and above is considered as obesity. The application of BMI in defining obesity implies that excess body weight (obesity) should correlate positively with excess body fat, but this may not be true in all situations as muscle builders can accumulate excess body weight without excess body fat[18].
Obesity can also be defined in terms of body fat percentage. Body fat percentage is usually measured using dual-energy absorptiometry and calculated as fat mass divided by the sum of fat mass + lean mass +bone mineral content[11]. Using body fat percentage (BF%), obesity is defined as BF% of more than 25% in men and 35% in women[7]. It is argued that while body fat percentage may give a better assessment of individual fat accumulation, the body mass index is a better tool for the evaluation of body fat on a population scale. Hence BMI is the most popular tool for population measurement of obesity.

The advantages of BMI as a measure of obesity lies in the fact that it has high specificity[19, 20]. The BMI, at the appropriate cut-off points, also correlates well with risks to developing certain chronic conditions and mortality from these conditions[21]. Another critical advantage of BMI is that measurement of the component parameters (height and weight) is easy, non-intrusive and non-invasive [22, 23].

The use of BMI for the measurement of obesity is not without criticisms and shortcomings. Body mass index has been criticised for its poor sensitivity[19]. There are reports that using BMI cut off point of 30kg/m^2 underestimates the proportion of people with obesity[19, 24]. Body mass index also "does not distinguish between fat mass, muscle mass and bone mass"[19]. A good example of the importance of this distinction is found in muscles builders. The mass of muscle accumulated by muscle builders contributes to the weight of the individual. This can result in individuals like athletes and other competitive sportsmen weighing more than appropriate for height, thus giving a high body mass index in the absence of excessive fat accumulation[25]. Furthermore, as an indirect measure of body fat that is independent of the age of the individual, changes in body fat proportion that occur with age are not reflected by BMI calculations. As age increases, the percentage of body fat increases in an individual while the muscle mass decreases. These natural alterations with age are not accounted for by BMI calculations[26]. Despite the above-mentioned shortcomings of body mass index, it remains the global gold standard for assessing obesity.

Other methods of measuring body fat and obesity include measurement of waist circumference, waist-hip ratio, skinfold thickness, bioelectrical impedance, magnetic resonance imaging, dual-energy absorptiometry etc.[10]. Waist circumference and waist-hip ratio tend to measure abdominal obesity only. Abdominal obesity is a significant risk factor for many cardiovascular and endocrine diseases. The waist circumference can be challenging to measure in individuals with BMI greater than 35[10].

The WHO classifies body weight per BMI into four broad categories namely: Underweight, Normal Weight, Overweight and Obese. Underweight and Obesity are each further sub-classified into three sub-categories. Underweight is sub-classified into mild thinness, moderate thinness and severe thinness. Obesity is sub-classified into Obese class I, class II and class III. Table 2.1 illustrates the WHO classification of BMI[27].

Table 2.1. Classification of Body Mass Index by WHO

Classification	**BMI (kg/m^2)**
Underweight	< 18.50
severe thinness	< 16.0
moderate thinness	16.0-16.99
mild thinness	17.0-18.49
Normal weight	18.50-24.99
Overweight	25.0-29.99
Obese	≥30.0
obese class I	30.0-34.99
obese class II	35.0-39.99
obese class III	≥ 40

2.2. Global Burden of Obesity

It is estimated that about 600 million adults aged 18 and above were obese in 2014. This represents about 13% of the global population of adults aged 18 years and above[4]. In fact, a new word, 'globesity' was created to describe the global epidemic of overweight and obesity, which is being monitored by the World Health Organisation through the global database on body mass index[28]. The highest burden of obesity was reported in 1990 from Nauru in Oceania, where more than three-quarters of the adult population were obese. Burundi has the lowest adult obesity rate of less than 4%.[29, 30]. In the United States, about 36.5% of adults were obese in 2011-2014, with females having a higher burden of obesity than males (38.3% and 34.3% respectively)[31]. Australia has a unique distribution of obesity among men and women of 27.5% in 2012[32]. Approximately 25% of European women are obese while 22% of the adult male population are obese[33]. Region-wise, southeast Asia is the region of the world with least obese men (3%) and women (7%) in 2014[33]. Africa has prevalence rates of 6% and 15% for adult males and females respectively[33]. While there are regional and ethnic differences in the obesity prevalence, women have consistently had a higher proportion of the adult obesity burden in all regions and countries.

There was a double-fold increase in the global prevalence of obesity from 6.4% in 1980 to 12.0% in 2008 and reaching 13% in 2014[4, 29]. The global alarm on the obesity epidemic was not just triggered by the absolute increase in the obesity prevalence over the 28-year period from 1980 to 2008, but also by the observed rate of increase. For example, it was observed that half of the rise in obesity prevalence from 1980 to 2008 happened over a period of 20 years (from 1980 to 2000) while the other half occurred over a period of 8 years, from 2000 to 2008[29]. Furthermore, obesity which was previously considered a condition of the affluent was observed to spread rapidly across borders, races, and socioeconomic status, involving the poor nations of the world, where obesity was then unimaginable

There are essential differences between the obesity burden in low- and middle-income countries when compared to high-income countries. While the prevalence of obesity is lower in low- and middle-income countries as compared to high-income countries, the rate of increase in recent times is faster in low-and middle-income countries [34]. In high-income countries, the prevalence of obesity has an inverse relationship with the socioeconomic status. This is not the same with low and middle-income countries, where the prevalence of obesity increases as the income level increases [30, 34]. The proportion of adult females in low- and middle-income countries who are obese is about double that of adult males. In high-income countries, male and female obesity is similar[30, 34]

The burden of obesity is best situated in the global burden of morbidity and mortality caused by obesity-associated diseases. Globally, an estimated 2.8 million people die annually from overweight- and obesity-associated diseases while 35.8 million Disability-Adjusted Life Years (DALYs) representing 2.3% of DALYs are caused by obesity and overweight-related diseases and conditions[6]. DALYs represent the number of years lost due to ill-health, disability or early death. Overweight and obesity account for nearly half of the global burden of diabetes. Similarly, almost a quarter of the burden of ischemic heart diseases can be attributed to overweight and obesity. Significant proportions of some cancers have obesity and overweight as major risk factors.
In conclusion, the global prevalence of obesity is increasing at epidemic proportions across all nations, races, gender and socio-economic class. The rate of increase in poor nations of the world appears to be higher than in rich countries. The increasing burden of obesity has great negative impacts on individual and public health, making the control of obesity an important global public health action.

2.3. Burden of Obesity in Nigeria

Sub-Saharan Africa, to which Nigeria belongs, has its own share of the obesity epidemic. There is a paucity of reliable data on the burden of adult obesity in Nigeria. A systematic review of 75 publications on obesity and overweight in Nigeria published between 2001 and 2012, found only 4 of the studies meeting the inclusion criteria. In the review, the prevalence of adult obesity varied from 8.1% to 22.2% underscoring the vast heterogenicity of the country[35]. Data for the 2008 demographic health survey indicated a national prevalence of female obesity of 5.2%[36]. In the same 2008, the World Health Organisation reported adult female obesity prevalence of 9% and adult male obesity prevalence of 5.1% giving an overall adult obesity prevalence of 7.1%[37]. The paucity of data on obesity in Nigeria is not surprising as undernutrition had taken the front burner in nutrition and weight research in Nigeria and other sub-Saharan African countries. There is, however, a growing recognition that Nigeria is undergoing nutritional transition and the problem of obesity is beginning to become an important public health issue. This transition is brought about by the rapid process of urbanization and westernization[36]. An important illustration of this fact can be found in the reported range of adult obesity prevalence in Nigeria. Lagos, which is the most urbanised and westernised city in Nigeria has the highest burden of adult obesity of 22.2% while Maiduguri, which is one of the least urbanised and westernised cities in Nigeria has the least prevalence of 8.1%[35]. A recent study of adults in the federal capital city of Nigeria reported obesity prevalence of 15% and 42% for adult males and females respectively[38]. The 2013 demographic health survey reported obesity prevalence rate of 25% for women in reproductive age

(15- 49 years), with an urban prevalence rate of 33% and rural prevalence rate of 18%[39]. Nigeria has a double burden of under-and over-nutrition and this brings additional challenges to the country's health system[36]. Per the 2008 Demographic Health Survey, 12% of the female population aged 15 – 49 years were underweight while 20.9% were either overweight or obese[40]. This is a clear illustration of the effect of nutritional transition which at a point saddles a country with the double challenge of combating undernutrition while at the same time preventing an epidemic of overnutrition.

In summary, reliable data on obesity in Nigeria is sparse. The few available data suggest a double burden of undernutrition and overnutrition. Obesity prevalence is in epidemic proportions in the well-urbanised cities of Nigeria.

2.4. Epidemiology of Obesity

Obesity is a multifaceted condition with multifactorial aetiology, involving complex interactions between genetics, environment and behaviour[10, 11]. Simply speaking, obesity results when there is a positive imbalance between energy intake and energy expenditure. Genetic, behavioural and environmental factors influence the tendency to take in excess calorie. Similarly, the tendency to reduce energy expenditure is also influenced by these factors. However, the factors that bring about this positive imbalance are complex both in their own merit and in their interactions with one another in the obesity aetiology line. The complex interactions between genetics, socioeconomic environment, physical environment, psychosocial environment and lifestyle that bring about the development of obesity have continued to be subject of scientific investigations till date. The interactions between these factors are exemplified by the simple observation that when individuals living in obesity-restricting environments migrate to the so-called obesogenic environments, the likelihood of weight gain increases but the extent of weight gain varies between the individuals according to genetic predisposition[41]. Again, the fact that the current global epidemic of obesity has raged on despite the little or no change in human genetic composition in the last three decades points to the fact that phenotypic expression of the predisposing polygenes required other necessary factors that have increased within this period. One of the factors that have risen rapidly in the past three decades is rapid industrialisation of many countries of the world creating environments that encourage the so-called obesogenic behaviours like consumption of high energy diets, less physical activity, increased sedentary life, more television watching among others. One could easily say from the epidemiological standpoint that the global obesity epidemic could have arisen from a maladaptive synergistic interaction between previously existing polygenic traits and obesogenic environmental and behavioural factors[41, 42]

2.4.1. Genetic Factors

There is abundant evidence to show that certain genetic issues predispose individuals to excessive weight gain and obesity. These genetic mutations lead to situations of poor regulation of appetite leading to excessive eating, deficiency of leptin, low basal metabolic rate, low lipid oxidation rate, high rate of adipose tissue lipoprotein lipase activity, down-expression of adiponectin and low rates of lipid metabolism among other effects[41, 43-45]. It is estimated that about 16-85% of BMI can be accounted for by hereditary factors[46-51]. Studies involving Nigerian populations indicated that BMI hereditability was in the range of 45-70%[43, 46, 52]. Also, hereditary factors account for 37-81% of waist circumference[53-55] and 35 – 63% of body fat percentage[52, 56-58].

Hereditary of obesity has both monogenic and polygenic basis. Monogenic obesity results from single gene mutations[11]. Monogenic inheritance accounts for a small proportion of obesity genetics while polygenic inheritance accounts for most of the obesity genetics[59]. Most monogenic obesity usually starts from childhood. Affected children mainly have severe obesity (Class II or III obesity)[59, 60]. Mutations of genes that code for Leptin and pro-opiomelanocortin have been strongly linked with the development of some forms of severe obesity in childhood with a monogenic inheritance pattern[45, 61, 62]. Furthermore, mutations in genes that code for the receptors of these molecules, leptin receptor and melanocortin receptor also lead to severe childhood obesity that is inherited in a monogenic manner[63-65]. These mutations lead to congenital leptin deficiency with associated excessive appetite and excessive eating (hyperphagia), decreased activity among other manifestations[63, 66]. The resultant obesity manifests in its severe forms in childhood and is highly hereditary[63]. Polygenic inheritance accounts for most of the genetic basis of obesity. The complexity of the obesity trait means that most forms of adult obesity are not inherited in a typical Mendelian pattern (recessive or dominant) through single gene mutations as seen in monogenic obesity. Most individuals who are genetically predisposed to obesity have a polygenic genetic predisposition, meaning that the phenotypic expression of such genetic traits requires significant contributory effect of other obesity-predisposing traits or activities[59]. Several genes have been discovered which contribute to obesity, but each of these genes makes little contribution to the development of obesity when standing alone [11, 67]. These polygenes are also found in individuals with normal weight or even lean weight[67]. The development of obesity for most individuals with polygenic predisposition requires varying levels of gene-gene interaction, gene-environment interactions, gene-diet interactions and gene-lifestyle

interactions or combinations[11, 59, 67-69]. Polygenic obesity is thought to contribute significantly to the growing obesity epidemic[70]. For example, individuals homozygous for the risk allele of the FTO (fat mass and obesity-associated) gene were found to have 1.67-fold higher odds of obesity compared to those that did not inherit the risk. More importantly, homozygosity for this risk allele was found in 16% of 38,759 adult participants in a study[70]. There is also a high level of heterogenicity of the polygenes between individuals. This means that the exact set of polygenes and their interactions that lead to obesity in one individual might not be same in another individual, thus making the polygenic basis of obesity a very complex entity and a subject of intensive research[67]. This has important implications for obesity risk prediction in any individual. Some studies have tried to develop genetic risk scores for predicting obesity in individuals, but this has met with varying degrees of successes[67, 71]. It is noteworthy that some of the genetic mutations can also be protective against obesity[67]. The identification of genes that contribute to obesity has therapeutic implications as the knowledge can be utilised to develop therapeutic targets towards preventing obesity[43].
In summary, genetic influences have been well established as important contributors to the development of obesity in an individual, both as monogenic inheritance resulting in severe obesity that usually starts from childhood and the more common polygenic traits that require other inherited and non-inherited interactions for obesity.

2.4.2. Dietary Factors

Dietary factors have long been associated with the increasing burden of obesity. The consumption of high-calorie foods is a major determinant of obesity[72]. It is a common observation that the development of the global epidemic in obesity paralleled the global rise in consumption of energy-dense foods and drinks. Consumption of high-calorie diet and low fruits and vegetables is obesogenic[73, 74]. Countries that have the highest increase in the consumption of energy-dense foods also have the highest impact on the obesity of epidemic[4]. Many countries are undergoing nutrition transition from low-calorie whole meal diets to high-calorie processed diets[75]. This transition parallels increasing urbanisation and westernisation being observed in these countries. The more industrialised nations have higher burdens of obesity while the less industrialised countries have lower burdens of obesity. Even amongst the low industrialised nations of sub-Saharan Africa, the burden of obesity increases as urbanisation increases. This accounts for the double burden of nutritional problems being experienced in low and middle-income countries of the world where undernutrition is a significant burden, especially in rural areas while obesity is an emerging problem in the urban areas. Nigeria is one of the countries currently experiencing nutritional transition and having a double burden of nutritional diseases. The nutritional transition experienced by migrants from less developed countries to developed countries also contribute to the observed increase in weight gain and obesity amongst such people.

Globalisation is linked to the nutritional transition and subsequent increase in obesity burden that is being observed globally. Globalisation and trade liberalisation has affected the nutritional transition of countries through "increased transnational trade of agricultural goods and processed high-calorie, high-fat foods, increased foreign direct investment in food processing and increased global advertising of processed energy-dense foods"[76, 77]. As part of the global response to the challenge of obesity, the World Health Organisation challenged food manufacturing industries to reduce the sugar and fat content of processed food, and decrease the marketing of high-calorie processed foods to the public[4].

The observed difference in the pattern of distribution of obesity between high-income countries and low-income countries also point to the role of diet in the development of obesity. In high-income countries of the world, obesity is observed to be more prevalent among the lower socioeconomic group while the high socioeconomic group in low-income countries suffer more from obesity. This parallels the dietary pattern in these countries. In high-income countries, the lower socioeconomic class consume the cheaper processed energy-dense foods while in low-income countries, the lower socioeconomic class consume more of the cheaper whole meals and vegetables[78]. The epidemiological evidence of the contribution of diet to the obesity epidemic is corroborated by evidence from clinical trials that have demonstrated the efficacy of very low energy diets in the management of obesity[79]. There is also evidence to show that the obesity in some developed countries increases as the quantity of food consumed by individuals within the population, the so-called portion-size increases[80-82]. Also, obesity increases as the quantity of energy-dense food consumed by the individual increases[83].

There is accumulating evidence to show that food affects the expression of genes. A unique field of study called nutrigenomics studies the effect of diet on the structure and function of the human genome. Evidence from the field of nutrigenomics has added new insights into the complex interaction between genetics, diet and environment in the aetiology of obesity as well as opening new frontiers in personalised prevention and management of obesity by dietary interventions [84-87].

To summarise, dietary patterns that support consumption of high energy foods and low intake of fruits and vegetables contribute to the development of obesity both at the individual and population levels.

2.4.3. Physical Activity

Physical activity is described as "bodily movement produced by contractions of skeletal muscles that result in varying amounts and rates of energy expenditure that are positively related to physical fitness and health, depending upon stimulus for physical activity such as its type, intensity, regularity and timing"[88]. Physical activity is different from exercise. Exercise is a kind of physical activity that is "planned, structured, repetitive, and purposeful"[89]. It is estimated that 30 – 70% of variations in the level of physical activity across individuals are accounted for by inheritable genetic factors. The inheritable traits that influence the individual level of physical activity are mediated through complex multifactorial interactions involving several polygenes, with each polygene contributing small effects in the variation of physical activity[88, 90-93].

Lack of physical activity is the 4th leading major risk factor for global mortality accounting for 6% of global deaths[89]. Physical inactivity is a major risk factor for several non-communicable diseases like cancer of the breast, cancer of the colon, diabetes, and ischaemic heart diseases. It is estimated that lack of physical activity is implicated as a cause of a quarter of breast and colon cancers and nearly a third of Ischaemic heart diseases[89] and obesity. The problem of physical inactivity is that it also acts synergistically with obesity to cause some important metabolic diseases[94]. This means that the problem of physical inactivity does not just end with causing obesity but goes far beyond. Physical activity falls under the broad category of lifestyle or behavioural factors.

Epidemiological evidence linking physical inactivity to obesity has shown consistent results across all income classes and across low-income, middle-income and high-income countries of the world[95, 96]. Evidence has shown that increasing the physical activity level of obese individuals leads to appreciable weight loss[97]. Increased physical activity works both independently and synergistically with other weight management methods to reduce obesity[98, 99]. Again, evidence abounds that the physical activity up to 30 minutes per day or 150 minutes per week helps prevent obesity. It is estimated that physical activity that results in the expenditure of 1 500 to 2 500 Kcal per week is needed to maintain weight loss[100]. It is estimated that less than 20% of the adult population do physical exercises at least 2 times a week[101]. Another important epidemiological observation is that the trend in the global obesity epidemic parallels that of physical inactivity and nutritional transition, further supporting the synergistic role of the three factors in the development of the global epidemic in obesity[102, 103].

Physical activity is an important modulator of the phenotypic expression of obesity polygenes[104]. Activity related genes that have been identified include EDNRB, MC4R, UCP1, FABP2, CASR, and SLC9A9 genes[93]. Research has also shown that several genes that modulate insulin action and adipocytokine signalling pathway were down-regulated during physical inactivity and up-regulated after introduction of physical activity, suggesting that decrease transport and metabolism of fatty acids might be one of the pathways through which lack of physical activity exerts negative effects on weight gain and metabolism[105]. Another metabolic pathway through which physical inactivity affects metabolism and weight gain involves increased inflammation and ceramide biosynthesis[106]. The impact of physical inactivity on obesity and that of physical activity to the prevention and management of obesity is an important area of contemporary research.

2.4.4. Built Environment Factors

The built environment has gained prominence as an important environmental factor in the aetiology of obesity. The built environment refers to “the human-made space in which people live, work, and recreate on a day-to-day basis”[107]. This includes the layout of the living space, buildings, recreational parks and transport systems. The relationship of the built environment to obesity is mediated through physical activity. The understanding is that the built environment has inductive or prohibitive influences on the level of individual and population physical activities. Thus, some built environments may encourage physical activities and others may not encourage physical activities. For example, people living or working in environments where walkability is not encouraged by the nature of the road layout or transport system tend to have reduced levels of physical activities. People living or working in places with safe and good road sidewalks tend to walk more than those living or working in areas without road sidewalks. Individuals living in areas with good and safe recreational parks tend to engage in more physical exercises than those living in areas without such facilities. Again, some built environment may encourage good dietary habits while some may encourage obesity-friendly dieting. Individuals living or working in environments with easy access to fast food shops tend to eat more of high-energy processed foods than those living or working in areas where such shops are not located.

The concept of obesogenic environments refers to built environments that tend to encourage obesogenic behaviours. Such obesogenic behaviours include low physical activities and consumption of energy-dense diets. In high-income countries, good road sidewalks and recreational parks are being constructed and these encourage physical activities of individuals living in these countries. One would have expected that the burden of obesity in such places would be low. High-income countries have high obesity burdens. The concomitant increase in consumption of high-energy diets and improved transport systems that reduce walking and cycling tend to offset the positive effects of the built environment in these places. In contrast, low and middle-income countries have poor networks of sidewalks and recreational parks that do not encourage physical activities. Prior to the obesity epidemic, these countries consumed less of processed foods with low energy content and have a low prevalence of obesity. However, all these are changing now with the nutritional transition in these countries which has seen the population consuming more and more processed foods with high energy content, with a concomitant increase in obesity burden.

Advances in the Geographical Information Systems have helped improve knowledge on the effect of built environment on body weight. Important information that can be used from Geographical Information Systems include the ease of measurement of distances between any given address to recreational facilities and fast food hubs as well as knowledge of the green space and walkability features of a given area. These advances have helped to bring to light, the complexity of the interaction between built environment and physical activity. For instance, some reports have indicated positive associations between high-density populations, street connectivity and physical activity yet others have reported low physical activity in areas with low population densities, good sidewalks and good street connectivity[108]. The presence of environmental features that encourage physical activity may be offset by other factors that discourage utilization of the features. For instance, the conditions of the sidewalks and not just the presence of sidewalks may be important factors that encourage walking and other physical activities[109]. The social environment also modifies the effect of built environment, physical activity and obesity[110]. Apart from the social environment, safety and perceptions of safety also modify the effect of built environment on physical activity. Irrespective of how physical activity-friendly a built environment is, a perception of lack of safety can minimize the utilization of the activity-friendly environment.

While some studies reported that the effect of built environment on the obesity burden of individuals and populations is independent of race, social status and economic status, others reported that the built environment has a differential influence on men and women.

2.4.5. Socioeconomic factors

Socioeconomic factors are important correlates of obesity. The effects of socioeconomic factors on the obesity epidemic appear to differ between nations. On a global level, high-income countries have higher burdens of obesity than low and middle-income countries of the world. Within high-income countries, individuals living in urban areas tend to have less obesity than those living in rural areas. On the other hand, individuals of lower socioeconomic status in high-income countries have higher obesity burden than individuals of higher socioeconomic status[111-116]. On the contrary, in low-income countries, individuals living in urban areas have a higher prevalence of obesity than those dwelling in rural areas. Individuals of higher socioeconomic status in low-income countries have higher obesity burden than those of lower socioeconomic status[117-122]. Reports from middle-income countries indicate a variable association between socioeconomic class and obesity[121, 123]. Report from South Africa indicates that individuals of high socioeconomic status tend to have a higher burden of obesity [123]. In Egypt, the prevalence of obesity is reported to show a similar trend across all socioeconomic groups[124]. The implication of this observation is that socioeconomic status might not have a direct effect on the development of obesity in all individuals but interacts with other factors like culture, societal perceptions, education and other lifestyle factors to influence the burden of obesity[125].

The association between socioeconomic factors appear to have some gender-specific variations. In Korea, while there is a positive association between individual income and body mass index, education did not have any association with body mass index in men. In women, the higher the level of education, the lower the prevalence of obesity while personal income did not have any association with body mass index[126]. In Northwest China, the socioeconomic class is positively associated with obesity in men. Women with lower education had a higher prevalence of obesity in China[127]. In Peruvian, women with higher income tend to be more obese than women with lower income while women with higher education tend to be less obese than women with lower education[118]. In Nigeria, available reports from studies, which evaluated restricted sections of the population suggest a positive association between higher socioeconomic class and obesity as well as between urban dwelling and obesity[38, 128].

In summary, socioeconomic factors are strongly associated with body mass index and obesity across all races, gender, and nations. However, the direction of this association differs across the Human Development Index of the countries and there are some gender-specific variations in some areas.

2.4.6. Cultural Factors

The culture of a community is one of the environmental factors that influence the population obesity burden. Culture affects the food habits, the perception of body size and the physical activity level of members of a community or ethnicity[129, 130]. The food habits of people that are affected by culture include the type of stable food considered to be healthy and the way of cooking food. In some cultures, like the Samoan, energy-density food is considered to be healthy. This will mean that Samoans strive to have meals rich in carbohydrates and fat. This could be one of the drivers of the high obesity rate in Samoa. Samoa has one of the highest adult obesity rates in the world of 57.5% in 2013[131] The cultural way of cooking in Nauru promotes obesogenic diets[132]. Nauru is also one the countries with the highest prevalence of obesity in the world.

Some cultures perceive large body size as a symbol of wealth and power. Polynesians view large body sites as representing wealth, prestige and power[16]. The culture in African American communities perceives large body sizes as a symbol of beauty and sexual attraction[129]. In Mauritania, fat women are considered attractive and of high socioeconomic status to the extent that young girls in some parts of rural Mauritania are force-fed in fat-farms to make them look attractive[133, 134]. This cultural practice is also found among some Niger Delta States in Nigeria. In Nauru, fatness is seen in women as evidence of fertility and in men as a symbol of power for traditional power competitions. Tahitians and Jamaicans revere large body sizes as a symbol of beauty. In fact, Jamaican young girls are reported to buy appetite stimulating pills to enable them to eat more and get fat and attractive to the men[135]. Stoutness is revered in among the Bamileke community in Cameroun. This societal norm has been reported as one of the factors that drive the high prevalence of obesity in Bamileke Cameroun[136]. In some cultures, the fatter the married women and children, the more appreciated the head of the household is as living up to his responsibility of providing enough food for the family. Such is the case in some parts of Mexico where larger body sizes for married women and children are viewed as a symbol of good life and affluence. Furthermore, in these parts of Mexico, obese women resist weight loss as it is viewed as a sign of illness[137]. Positive societal perception of obesity is reported as one of the contributory factors to the high prevalence of obesity in the country[138]. Some cultural practices of Muslim communities and cultural understanding of large body size have been reported to contribute to the high obesity level found in such communities in Sri Lanka, Morocco and North West England[139-141].

In summary, culture impacts on obesity through societal veneration of large body size, which has been linked to obesity in some countries of the world, as well as through obesogenic food habits of a society. In Nigeria, obesity is culturally and socially acceptable and not usually recognized as a medical problem [13]. Obesity is generally viewed as a sign of wealth, power and beauty in many parts of Nigeria, especially the southeastern part. In some cultures, in southern Nigeria, prospective brides are kept in 'fattening' rooms for months to make them fat enough and more appealing to their prospective grooms [14, 142].

2.4.7. Psychological Factors

Psychological factors are yet another environmental factor that interacts with other factors in the development of obesity. Clusters of obesity within social ties, social networks and households are being recognized. The chance of an individual to develop obesity is higher if the spouse is obese. The same relationship has also been found among siblings and among friends. This has led to the phenomenon of the so-called 'social contagiousness' of obesity. These effects are mediated through psychological mechanisms. Spouses, siblings and friends may share similar norms and ideas about ideal body size, and these norms and ideas can influence obesity-related behaviours and lifestyles like dietary habit and physical activity[143, 144]. For example, binge eating has been reported to be socially contagious among peers[145]. Another mechanism through which psychology influence the development of obesity among social ties is that friends, siblings and spouses do share similar or same environment. Consequently, they carry out similar obesity-friendly activities like eating outside and others. This is distinct from the effect of sharing norms and ideas about ideal body size, which in turn influences obesity-related activities[146]. The work of Christakis and colleagues published in 2007 brought to the fore the social-contagiousness of obesity but Hruschka and colleagues in 2011 distilled out the contribution of shared social norms and ideals to the social-contagiousness of obesity[143, 146]. Christakis and colleagues found out that an individual has 57% chance of getting obese if his friend is obese while an individual has 40% chance of getting obese if a sibling is obese. Furthermore, the same gender was found to have a greater influence towards socially-transmitting obesity to the friend or sibling than opposite gender. The chance of a wife or a husband getting obese is 37% if the spouse is obese[143]. Building on the work of Christakis and colleagues, Hruschka and colleagues found out that about 20% of the social-contagiousness of obesity is 'transmitted' through shared norms and ideals. A majority was transmitted by sharing the same environment and the same activities that contribute to excessive weight gain[146]. The social-contagiousness theory of obesity was further supported by findings that the rate of increase in obesity is 0.5% points for each obese social contact, thus suggesting both a spontaneous and transmissive increase in the global prevalence of obesity. The interesting thing here is that it was also found that recovery from obesity is independent of the number of normal weight contacts, thus suggesting no contribution from a decreasing rate of weight loss as a driver to the global obesity epidemic[147].

In summary, there is evidence to support the contribution of psychological factors, mediated through a combination of shared norms of ideal body size and shared environment/surroundings, in the aetiology of individual obesity and the rising burden of the global obesity epidemic.

2.4.8. Role of viruses

There is evidence that viruses contribute to the aetiology of obesity in humans. Animal studies have suggested possible a pathway through which some viruses may contribute to the development of obesity in humans. Adenoviruses are the most implicated in this regard. Adenovirus AD-5, Ad-9, AD-31, AD-36 and AD-37 are human Adenovirus subtypes that have been linked to obesity[148]. Human adenovirus 36 is the most extensively studied adenovirus regarding the role of viruses in the aetiology of human obesity. AD-36 stimulate enzymes that cause accumulation of triglycerides, which are a type of fat in the body[149]. Accumulation of triglyceride has been shown to strongly correlate to abdominal obesity, with obese individuals having higher levels of triglycerides in their blood[150]. The viruses also stimulate transcription factors that cause the differentiation of pre-adipocytes to mature adipocytes, which are the storehouse of human fat[149]. Furthermore, the AD-36 virus reduces leptin gene expression in a way that leads to overeating and excess accumulation of fat[151, 152]. Leptin is a hormone secreted mainly by fat cells that inhibits hunger, reduces food intake and promotes energy expenditure, thereby causing a negative energy balance, which is anti-obesity[153]. Human adenovirus 36 is found in 30% of obese humans and 11% of non-obese humans[154].

In summary, infection with certain strains of viruses, especially some subtypes of human adenoviruses may contribute to the development of obesity in an individual mainly through alteration of genetic pathways for genes that regulate appetite hormones and production of fat cells in the body. The most studied of these viruses is human adenovirus 36 which is found in a significantly higher proportion of obese humans than non-obese humans.

2.5. Complications of Obesity

Obesity is associated with numerous complications. Obesity is a risk factor in many non-communicable diseases that account for a significant proportion of deaths worldwide. The complications associated with obesity extends beyond physical diseases and death to involve psychological and emotional disturbances. It is the huge risk that accompanies obesity that has made obesity a disease with huge global public health importance. This is coupled with the fact that obesity prevalence worldwide is neither stabilizing nor slowing but rather increasing at an alarming rate. Understanding the complications associated with obesity brings to reality the dangers of the rampaging global obesity epidemic.

2.5.1. Obesity and Diseases

Obesity is a well-known risk factor in the development of a myriad of diseases and disease conditions. Obesity is implicated as a risk factor in diseases of almost all the systems of the human body. These systems include the cardiovascular system, cerebrovascular system, metabolic system, neurological system, respiratory system, musculoskeletal system, dermatological system, and others.

Some of the metabolic diseases in which obesity is a risk factor include Diabetes Mellitus, gallbladder disease and Hyperlipidemia[155-159]. Obesity predisposes to type 2 diabetes by causing increased insulin resistance[155]. Hu and colleagues observed 3 300 new cases of diabetes over a 16-year long follow up of 84 941 female nurses and reported obesity to be the single most important predictor of type 2 diabetes[156]. In males with BMI more than 35kg/m^2, the age-adjusted relative risk for developing type 2 diabetes is 60.9 when compared with males with BMI less than 23kg/m^2 [160].

Cardiovascular diseases associated with obesity include hypertension and coronary heart diseases among others. The relative risk for cardiovascular diseases in obese men is 1.46 and 1.64 in obese women when compared to non-obese men and non-obese women respectively. Similarly, the population attributable risk for developing hypertension in men and women with BMI of 25kg/m^2 and above is 26% and 28% respectively. The population attributable risk to developing angina pectoris in obese men and women is 26% and 22% respectively. For coronary heart disease, the population attributable risk to obesity is 23% in men and 15% in women[157]. In the Asia Pacific cohort study in which 115 818 women aged 30-35 years were followed up for 14 years, a unit change in BMI was found to produce a 9% increase in events of ischaemic heart diseases[161]. The risk of developing heart failure is reported to increase two-fold in obese persons when compared to non-obese persons. However, there is an unexplained paradox in which the overall survival in patients with heart failure is better with obese persons than with non-obese persons[162]. The risk of stroke was found to increase with increasing BMI in the Korean study in which 234 863 persons were followed up for 9 years[163]. Kurth and colleagues followed up 39 053 women for 10 years and reported a hazard ratio of 1.5 for total stroke, 1.72 for ischaemic stroke and 0.82 for haemorrhagic stroke in obese women[164].

The respiratory diseases associated with obesity include asthma and obstructive sleep apnoea[159, 165]. Obesity causes excess fat deposition in the airway. The increased adipose tissue mass in the airway causes mechanical narrowing of the airway calibre. Furthermore, fat on its own causes increased collapsibility of the airway[165].

The musculoskeletal conditions that arise from obesity include osteoarthritis, chronic pain, low back pain, and tibia vara while the neurological diseases include anxiety and depression[159, 166]. Massive localised lymphedema is one of the important dermatological conditions that have been reported increasingly in recent times in association with obesity[167, 168].

In obstetrics, obesity predisposes to gestational diabetes mellitus, pregnancy-induced-hypertension, pre-eclampsia, preterm birth, large for date babies, fetal defects, perinatal death, increased caesarean section rate, delayed initiation of breastfeeding and early cessation of breastfeeding[169, 170].

In Gynaecology, polycystic ovary syndrome and endometrial cancers are some of the diseases associated with obesity[171]. Obesity also complicates surgical operations by making surgeries more difficult, increasing wound infection, and wound breakdown. Obesity increases the risk of some important cancers. In 2012, about 481 000 new cancer cases in adults aged 30 years and above worldwide were attributable to high BMI. This represents about 3.6% of all new cancer cases[172]. The risk of endometrial cancer increases as the body weight increases the risk to between 2 and 4-fold for obese women and 7-fold for extremely obese women[173]. The risk of oesophagal adenocarcinoma is also increased 2-fold in obese persons compared to normal weight persons. This risk increases to four-fold in obese class III individuals[174]. A recent meta-analysis that involved more than 10 million individuals in 24 prospective studies by Chen and colleagues found a strong positive association between obesity and gastric cardia cancer[175]. Liver cancer is yet another cancer that has been linked to obesity. A recent meta-analysis of 26 prospective studies with 25 337 cases of primary liver carcinoma found a summary relative risk of 1.83 for developing liver cancer in obese individuals when compared with their non-obese counterparts. This risk was higher for men than women and independent of other risk factors for primary liver cancer like Hepatitis B infection, Hepatitis C infection, alcohol consumption, and geographic location[176]. Other meta-analyses also reported similar results[177-179]. As a risk factor for kidney cancer, obesity almost doubles the risk of renal cell carcinoma when compared to non-obese. The risk increases by 4% for each unit increase in BMI[180]. The association between kidney cancer and obesity is independent of the association between kidney cancer and hypertension[181]. Multiple myeloma, meningioma, pancreatic cancer and colorectal cancer are also associated with obesity with the increased risk in obese persons ranging between 20% to

50% when compared to non-obese persons[182-185]. Obese individuals have a 60% increased risk of gallbladder cancer more than non-obese individuals, with men having a higher risk than women[186]. Breast cancer in postmenopausal women has been known to be higher among women with high BMI, especially for receptor-positive postmenopausal breast cancer and in both male and female breast cancers [187-189]. For each 5 unit increase in BMI, there is a concomitant 10% increase in the risk for thyroid cancer and ovarian cancers in never-users of hormone therapy[190, 191].

Despite the huge evidence linking obesity as an important independent risk factor in the development of many cancers, the exact pathway through which obesity has not been conclusively elucidated in all cases, hence there are several theories on the aetiological pathway. In breast cancer, ovarian cancer, endometrial cancer and others, it is suspected that the increased secretion of oestrogen from fat tissues could be responsible. The chronic low-level inflammation found in obese people is thought to be responsible for certain cancer development as such inflammation is thought to have the capacity to damage DNA of cells[192]. Another possible pathway is through the increased production of insulin and insulin-like growth factor 1. Obese individuals produce high levels of insulin and insulin growth factor 1 in their body. Increased levels of these compounds in the body have been implicated in the development of colon, prostate, renal and endometrial cancers and treating obesity reduces the risk of these cancers[193]. Leptin is a hormone excess in many obese people as many obese adults have Leptin resistance. Leptin is at the centre of the genetic basis of obesity. This hormone promotes cellular growth and may have a role in cancer development and or cancer progression. Similarly, a hormone called adiponectin, which has anti-proliferative properties to cells have been found to be deficient in obese individuals. This could play a role in promoting cellular proliferation as its deficiency would create a supportive environment for cellular proliferation[194]. Both leptin and adiponectin belong to a group of hormones called adipokines, which are mainly produced by adipocytes (fat cells) in the human body.

2.5.2. Obesity and Mortality

Ranking 6th in hierarchical importance among the risk factors that contribute to the global disease burden, obesity is a notable independent risk factor for increased mortality and premature death in all races, ethnicities and ages[195-197]. Globally, excess body weight causes more deaths than underweight as more of the world's population live in areas where obesity cause more deaths than underweight[4]. The risk of death conferred on an obese individual by excess body fat is about 2-3 times that of a non-obese individual[196]. In the United States, obesity is reported to hasten an individual non-smoker's death by 9.4 years[198]. For some time now, one of the recognized paradoxes of obesity was the report that overweight but not obesity protects against mortality[199, 200]. This led to confusion as to what an ideal body weight should be. However, a recent large intercontinental study involving the review of 239 large studies and more than 10 million participants across 32 countries of the world, and with the participants followed for an average of 14 years, has helped resolve majority of the controversy[201]. The study reported that normal weight individuals have the lowest mortality risk. It noted a trend towards increased mortality as the BMI increases above 25kg/m^2. Individuals with BMI 25 -<27.5kg/m^2 have 7% higher mortality risk than individuals of normal weight. A BMI of 27.5 – <30kg/m^2 confers a 20% higher mortality risk while individuals with BMI of 30 - <35kg/m^2 have 45% higher chance of death than normal weight individuals. This risk increases to 94% for individuals with BMI of 35 - <40kg/m^2. Indeed, every 5 unit increase in BMI above 25kg/m^2 is associated with 31% higher risk of premature death[201].

Looking at the specific causes of mortality linked to obesity, each 5 unit increase in BMI above 25kg/m^2 increases the risk of death from cardiovascular diseases by 49%, the risk of death from respiratory diseases by 38% and the risk of death from cancers by 19%. These risks are more for younger individuals than older individuals from both sexes and more in men than women[201].
In summary, obesity has been established to be an important independent determinant of early death in all individuals irrespective of age, sex, race or ethnicity. The risk shows an incremental gradient with increasing BMI above the cut-off value for normal weight, 25kg/m^2. Previously-held notion that being in the overweight BMI category is protective against mortality has been proven to be false.

2.6. Economic Cost of Obesity

The global epidemic of obesity has immense economic implications both for the individual and for the national health systems. Obesity incurs cost to the individual and the health system through cost of weight loss consultations and programs, cost of public awareness campaigns against obesity, cost of treatment of obesity-related diseases, cost of treatment of obesity itself, loss of work hours to morbidity associated with obesity, lowered employment possibility, lowered personal income and lowered quality of life[202]. The extra cost to the individual negatively affects the proportion of the family income that is available for other essential family needs like feeding, education, housing and others. These health expenditures become most felt in resource-constrained countries especially those with little or no functional health insurance coverage like Nigeria. In these countries, a majority of health expenditure is individual out-of-pocket expenditure, the so-called catastrophic health expenditure. Even in high-income countries, obesity causes an avoidable drain on the national health insurance system as well as on individual incomes. The Medicaid program in the United States, which is a public health insurance program for individuals and families with limited resources for health care, spends a whopping $8 billion a year to defray costs related to the treatment of severe obesity and its complications[203].

In the United States of America, an obese adult is estimated to spend additional $3 900 more in medical expenditure within the first year of obesity than the non-obese counterpart rising to $4 600 additional expenditure in the 10th year and $4 820 after 10 years[202]. The higher the BMI, the higher the additional cost. For instance, after 10 years of obesity, the average excess annual health expenditure that is attributable to obesity of all classes is $4 820 but the figure for class I obesity is $2 820, for class II obesity, it is $5 100 and $8 700 for class III obesity. For each excess kilogram of weight, the estimated additional cost for all classes of obesity is $140[202]. In the same United States of America, the annual cost of common non-bariatric and non-obstetric surgeries has been estimated to be $160 million higher in obese persons when compared to non-obese persons on a nationwide basis[204]. For surgeries like mastectomy and breast conservative surgeries, obese patients pay 23% and 29% higher respectively. This translates to about $1 826 higher for the obese patient for breast cancer surgeries and $1 702 higher for the obese patient for breast conservative surgeries[205]. These additional expenses are quite huge considering the fact that the national minimum wage in the United States is $1 160 per month[206]. More so, 30% of the cost of severe obesity is paid out-of-pocket, 41% by public health insurance and 27% by private health insurance[203].

At the national level, the direct cost of obesity is estimated at between 5 and 10% of USA health care spending[207]. It important to note that the total cost of obesity comprises direct medical costs and indirect medical costs, with indirect medical costs accounting for 59% 0f the total estimated cost[208]. Brazil spends a sizeable part of its national healthcare cost on obesity and obesity-related diseases, which accounts for about $1.4 billion in healthcare expenditure in 2012. This constitutes a heavy burden on the Brazilian health care system[209]. The total cost of obesity in Thailand is estimated to be $725.3 million, which is equivalent to 0.13% of the GDP of Thailand[210]. In China, physical inactivity, which is responsible for about 16% of the risks associated with the five major non-communicable diseases, namely coronary heart disease, stroke, hypertension, cancer and type 2 diabetes, is also responsible for 15% of the medical and non-medical cost of the main NCDs in China[211].

Obesity does not just affect the individual and the health system but also affects the employers. In the United States of America, an employer spends an average of $3 830 annually on covered medical cost, sick day, short-term disability and workers' compensation claim for normal weight, and $8 067 for a morbidly obese employee in 2011.

2.7. Psychosocial Implications of Obesity

Obesity is associated with quite a few important psychological consequences. With few exceptions where some cultures revere and venerate fatness and large body mass, most of modern civilization tends to lean towards 'the slim' body. This together with the huge global anti-obesity campaign, creates important psychological issues for obese individuals. These issues include low self-esteem, body dissatisfaction, social stigmatization, anxiety, depression, eating disorders, substance abuse and low quality of life[212-218]. Nigeria appears to be one of the exceptions to this drive for the slim body. The perceptions of large body size and its impact on obesity are one of the objectives of this study.

Obese individuals are more likely to suffer discrimination in social circles and workplaces. This discrimination results from negative stereotypes attached to obesity by most societies. These negative stereotypes include laziness, lack of self-discipline, inefficiency, and work refusal. Obese individuals who suffer from these stigmatizations eventually internalize these negative stereotypes leading to self-stigmatization, loss of self-esteem, self-efficiency, depression, eating disorders and anti-social behaviours[215, 216]. All types of self-esteem namely physical self-esteem, professional self-esteem, and emotional self-esteem have been reported to be reduced in obese persons because of social stigmatization[8]. The feeling of low self-worth makes the obese individual to feel less attractive and this could account for the reported increased tendency of obese women towards multiple sexual partners, dating of older men and risky sexual behaviours when compared non-obese women[219].

In Poland, about 5.3% of obese women reported discrimination at the workplace. Similarly, 10.5% of obese women in Poland reported being victims of verbal abuse consequent upon their body size at the workplace leading to lack of motivation and over-eating[217]. Obese persons are also less likely to get jobs of their choices due to their body size, as larger body sizes are stereotyped to be associated with laziness, sloppiness and work absenteeism[220]. It is worthy to note that stigmatization and discrimination run a vicious cycle with obesity, as obesity causes social stigmatization and discrimination while stigmatized obese individuals tend to engage in binge eating disorders leading to the addition of more weight. Sutin and colleagues recently reported that obese individuals who suffer discrimination are 3 times more likely to remain obese 4 years later compared to those that did not suffer any such discrimination[221].

Between 20 – 70% of obese patients are reported to suffer from psychiatric disorders[214, 215]. Obese individuals are reported to be 6 times more likely to develop generalized anxiety disorder and 5 times more likely to develop major depressive disorder compared to the non-obese counterpart[222].

In summary, obesity has profound psychosocial implications for the individual. Majority of the psychosocial implications stems from negative societal stereotypes for fat persons, which get internalized by obese individuals eventually creating a situation of loss of self-esteem, self-worth and body-size satisfaction.

2.8. Global Action Against Obesity

The recognition of the dangers of the obesity epidemic has prompted several actions against obesity both at the national levels and the global level. The aim is to halt and then reverse the growing burden and epidemic of obesity. Achieving this aim would mean a reduction in the number of DALYs attributable to obesity as well as the number of deaths attributable to obesity. The benefits of these will be felt both at the individual level and the national level. At the individual level, the physical, social, psychological and economic morbidities posed by obesity to the individual and the family will be minimized leading to better personal and interpersonal quality of life. Family income will improve directly through more income as the reduction of body weight improves employment opportunities and reduces the number of days lost due to ill health and absenteeism, as well as indirectly through the reduction of the proportion of family income spent on obesity-related diseases and obesity management. At the national level, the health system will be strengthened as there will be more funds available to manage other pressing national health and developmental issues.

The WHO is coordinating the global action against obesity. The WHO first alerted the world to the emerging global obesity epidemic in the 1990s. Since then the WHO has continued to spearhead the global action against obesity through a multi-pronged approach that included the "series of technical and expert consultations, public awareness campaigns and development of strategies to make healthy choices easier to make"[28]. The WHO public awareness campaign is aimed at galvanizing policy makers, medical professionals, the public and other relevant stakeholders in health to take up personal and public actions against obesity in an integrative and purposeful manner. In the light of the realization of the complexity of the obesity epidemic, only a well-coordinated and integrated multidisciplinary approach can make headway towards taming the obesity wildfire. As part of its global action against obesity, the WHO has also launched a collaborative effort with the University of Sydney, Australia to calculate "the worldwide economic impact of overweight and obesity". The WHO is also collaborating with the University of Auckland, New Zealand to "analyze the impact of globalisation and rapid socioeconomic transition on nutrition and identify main political, socioeconomic, cultural and physical factors that promote obesogenic environments"[28]. The term "globesity" was coined by the WHO to represent the global epidemic of overweight and obesity. The WHO also maintains a global database on body mass index to monitor the population weight profile of countries and regions of the world[28]. In 2004, the World Health Assembly adopted the WHO Global Strategy on Diet, Physical Activity and Health. This strategy was a set of actions initiated by the Who to galvanize nations to put in place all necessary policies and commitments towards a healthy lifestyle at the population level[4]. In the year 2011, the Heads of States and Governments of the United Nations Organisation endorsed the UN political declaration on non-communicable diseases. Consequently, the WHO developed the "Global Action Plan for the Prevention and Control of Noncommunicable Diseases 2013-2020". This action plan includes among other things, the strategy to halt the rising global obesity epidemic and to reverse the globesity rate to the 2010 value by 2025[4].

At the national level, many countries of the world have adopted national strategies and policies towards reducing the obesity epidemic. At the core of the national strategies are public awareness campaigns on the dangers of obesity and the health benefits of physical activities, legislation to reduce the caloric contents of processed foods through higher taxation, and stricter regulation for food labelling and food advertising. For instance, in 2013, Mexico rolled out a comprehensive national anti-globesity strategy, which included an aggressive anti-globesity public awareness campaign, and "increased regulatory framework on processed food labelling and advertising". This was followed in 2014 by increased taxation of 8% tax on "food with high energy content and sugar-sweetened beverages"[223]. Similarly, the regulatory framework and increased taxation adopted by Hungary in 2011 lead to a 29% increase in prices of taxed foods and 27% decrease in consumption. The extra revenue from taxation was ploughed back into the national health budget and health workers salaries[223].

The Bank of America Merrill Lynch in 2012 launched investment portfolios towards fighting the global obesity epidemic. The investment portfolio sought to increase private investment in 4 critical areas of anti-globesity namely: "pharmaceuticals and health products, food, commercial weight loss, diet management and nutrition, and sports apparel and equipment"[224].
The world obesity federation is also at the forefront of the global action against obesity. As part of its anti-globesity activities, the world obesity federation is collaborating with a leading international

journal, The Lancet, the University of Auckland, New Zealand, and the George Washington University, USA, in a broad effort to stimulate action on anti-globesity and "strengthen accountability systems for the implementation of agreed recommendations to reduce obesity and its related inequalities"[225].

In summary, there are enormous efforts on the global scale to halt the growing epidemic of obesity. These efforts are both at the national and international level. Policies to reduce the caloric content of processed foods, increase the healthiness of consumed foods, discourage the production, advertising and consumption of obesogenic foods, and encourage and increase the uptake of physical activities are at the core of the global action against obesity. Nigeria is yet to officially recognize the inherent dangers to high-calorie processed foods, hence there is no policy to discourage their import into the country. This study evaluates the impact of carbonated sweet drinks, full meal intake and fruit intake on obesity and overweight.

CHAPTER 3

3. Rationale and Objectives

3.1. Rationale of the study

The obesity epidemic is spreading across the globe in hitherto unimaginable rates, breaking through boundaries of race, nationality, ethnicity, income and socio-economic status. Considering the rate of spread of the obesity epidemic and the plethora of associated diseases, with their high morbidity and mortality, obesity can be considered as a highly-challenging public health problem requiring an integrated population approach to halt the epidemic. Furthermore, the complexity of the pathogenesis of the obesity epidemic which involves complex interactions between genetics, diet, and environmental factors, means that there will be no one-size-fits-all solution that will apply to every culture, race and nationality of the world. The weight of the contribution of the various epidemiological factors of obesity in the obesity epidemic differs from one culture to another culture, from one population to another population and from one environment to another. For example, the relative contribution of the socioeconomic status of the individual to the population BMI is not same in high-income well-educated population in Europe as in a high-income well-educated population in sub-Saharan Africa. While socioeconomic status has an inverse relationship to obesity in a high-income well-educated population in Europe, it has a direct correlation to obesity in a similar population in sub-Saharan Africa. This implies that other interacting factors modulate the impact of socioeconomic factors on obesity in any given community. It then becomes imperative that the epidemiological factors operating in any given society must be well-understood as well as the relative interactions between the factors before an effective strategy can be formulated to curb the obesity epidemic within the population.

The epidemiology of obesity in other continents of the world is well known and documented. However, data on obesity in Africa, especially sub-Saharan Africa remains scant, doubtful and inadequately documented. Obesity and obesity-related diseases abound in the region. From the global health perspective, understanding the epidemiology of obesity in Africa remains a significant challenge. The low-income status of sub-Saharan African countries and their peculiar social environment makes it the more challenging and interesting.

Nigeria is a highly-populated nation, being the most populous country in Africa and the most populous black country in the world, with a total population of more than 160 million people. At least one in every five blacks in Africa is a Nigerian. The country is at the moment in the early phases of demographic and nutritional transition, common to many sub-Saharan African countries. The

strength of health care delivery in Nigeria and indeed Africa is in prevention and obesity is a preventable condition. Socio-behavioral and environmental modifications are essential components of obesity prevention and management. Nigeria has three major but very heterogeneous ethnic groups namely, Igbo, Hausa and Yoruba. There are several other minor ethnic groups in Nigeria, but most of the minor groups have similar characteristics to one of the three major groups.
Tackling obesity at the national level in Nigeria will present particular challenges that will require a good understanding of the epidemiological factors and their relative contributions to the development of obesity within the different major ethnic groups. Knowledge of epidemiological determinants of obesity in any given setting will go a long way in helping to evolve preventive strategies relevant to the environment and other similar settings. The study setting, Enugu state Nigeria, was the capital of the former Eastern Nigeria region when the country was divided into three administrative regions namely Northern Nigeria, Western Nigeria and Eastern Nigeria. Eastern Nigeria is the home of one of the major ethnic groups in Nigeria, the Igbo ethnic group. It is expected that data from this study will provide relevant information that will aid the evolution of policies on prevention of obesity in Nigeria.

3.2. Objectives of the study

The general aim of the study is to determine the prevalence and epidemiological factors of adult obesity in Enugu southeast Nigeria.
The specific objectives are as follows:

a. To determine the prevalence of obesity and overweight among individuals aged 20 to 60 years of age in Enugu southeast Nigeria.
b. To determine the relationship between BMI and Waist Circumference and Triceps Skinfold Thickness
c. To determine the sociodemographic risk factors for obesity and overweight among individuals aged 20 to 60 years of age in Enugu southeast Nigeria.
d. To determine the behavioural risk factors for obesity and overweight among individuals aged 20 to 60 years of age in Enugu southeast Nigeria.
e. To determine the perceptions of body size and its correlation to obesity and overweight among individuals aged 20 to 60 years of age in Enugu southeast Nigeria.

CHAPTER 4

4. Method

4.1. Study setting and population

Nigeria comprises 36 states of which Enugu state is one. The state has a population of approximately 3.3 million people comprising 1.6 million males and 1.7 million females. The population of individuals aged 20 – 60 years of age is 1.6 million per the 2006 national population census[17]. The state lies in an area of 7,161 Km^2. The hottest month of the year is February and the coldest month is December with average temperatures of 30.6^oC and 15.9^oC respectively. The state has a population density of 456/km^2[226]. The state has the largest coal deposit in Africa and thus popularly called the coal city state. Enugu is the name of the capital of the state and was the capital of the former Eastern Nigeria region, at a time when the entire country was divided into three regions for administrative purposes. These regions were Northern Nigeria, Western Nigeria and Eastern Nigeria regions. The indigenous people of Enugu State are the Igbo tribe, which is one of the three major tribes of Nigeria. The other two major tribes are the Hausas and the Yorubas.

For administrative purposes, each state in Nigeria is divided into local administrative units called Local Government Areas (LGA). Each LGA mirrors the government structure of the state and federal governments with its full complement of government structure namely, the executive, legislative and judicial arms of government. Enugu State has 17 of such local government areas. Three of the 17 LGAs are located within the urban areas while the rest are located within rural areas. The three urban LGAs are Enugu North, Enugu East and Enugu South LGAs. The rural LGAs are Aninri, Awgu, Igbo-Etiti, Igbo-Eze North, Igbo-Eze South, Isi-Uzo, Ezeagu, Nkanu-East, Nkanu-West, Nsukka, Oji River, Udenu, Udi, Uzo-Uwani LGAs. About 70% of the population of the state live in rural areas while 30% live in urban areas. Majority of Enugu population (62%) are classified as poor while about 38% are classified as non-poor in 2012 by the Nigerian Bureau of Statistics[227].

For ease of census data collection, the Nigerian National Population Commission divided each state of the federation into distinct geographical areas with distinct geographic boundaries called enumeration areas (EA). Each EAs has a cartographic drawing showing its geographic boundaries and the number of households at the last National Census exercise in 2006. Enugu state has a total of 13,998 EAs.

4.2. Study design

The study is a cross-sectional household population survey of adults aged from 20 to 60 years.

4.3. Sample size determination

The sample size estimation indicated that a minimum sample size of 6452 adults would be required for the survey. The assumptions that were considered in arriving at the sample size were as follows:

- National obesity prevalence of 8% (from the 2013 Demographic Health Survey [DHS]).
- Confidence interval width of ±1%.
- Confidence coefficient of 95%.
- Estimated Design Effect of 2.24 (from 2013 DHS).
- Estimated response rate of 98% (from 2013 DHS).
- Average eligible person per household of 4 (from 2013 DHS).
- Number of clusters = 30 (minimum acceptable number in cluster studies).

4.4. Sampling

The state was divided into urban and rural strata. Urban population make up 30% of the Enugu state population while the rural population make up 70% of the state population. Cluster randomised sampling was done. Government-defined population enumeration areas (EA) with definite geographical boundaries served as clusters for this study. Each EA is estimated to contain approximately 54 households, and each household is estimated to contain an average of 4 adults, giving 216 adults per cluster. The geographical boundaries of the EAs were predefined by the government through the National Population Commission of Nigeria. Figures 4.1 and 4.2 show the cartographic representations of an urban and a rural enumeration area respectively.
All consenting households in each cluster were sampled. All consenting adults aged 20 to 60 years in each household were sampled. Where the estimated number of adults in a cluster was not achieved, the next adjoining EA was entirely sampled in addition.

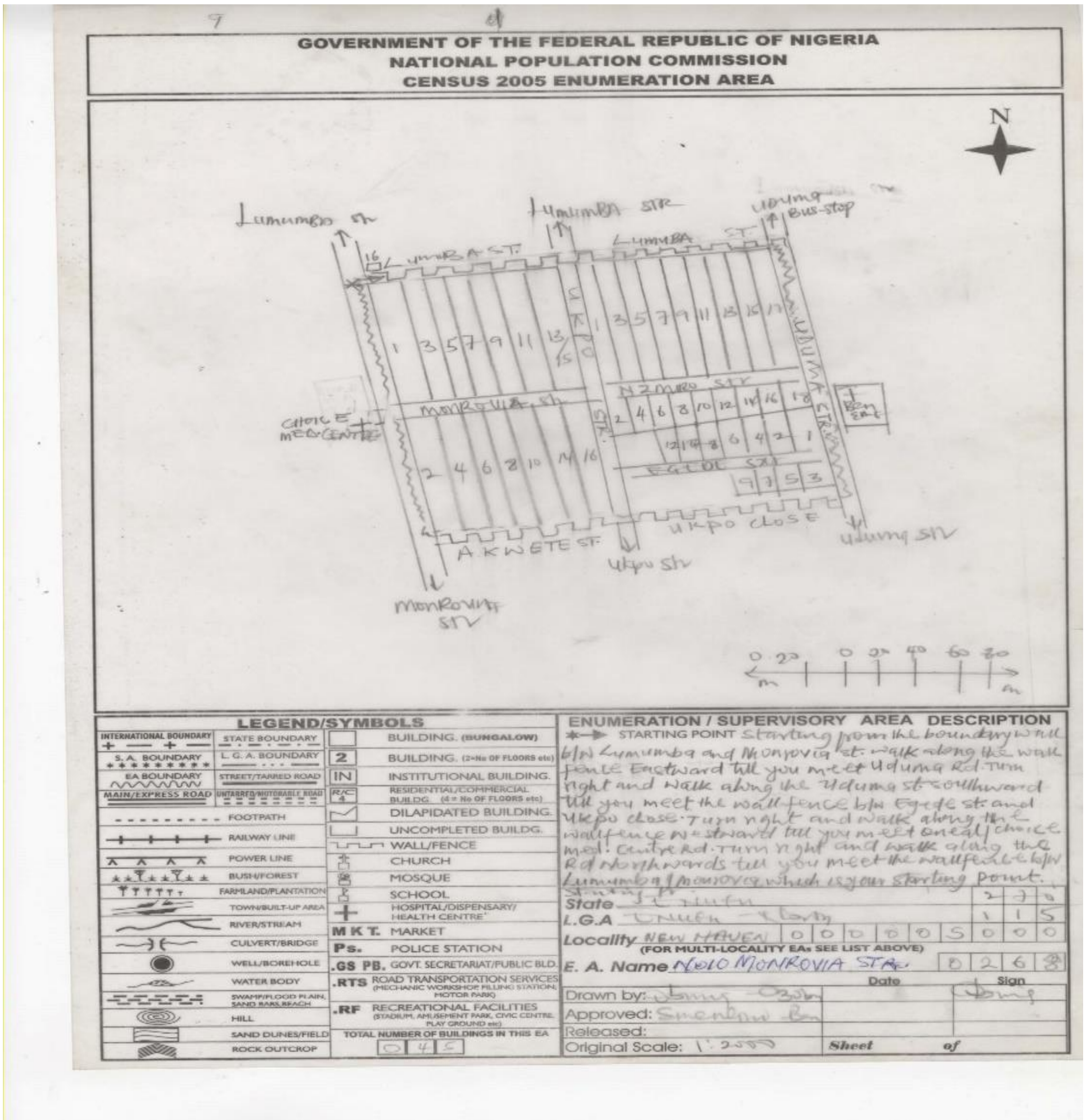


Figure 4.1. Cartographic representation of one of the urban EAs *(Source: National Population Commission, Nigeria)*

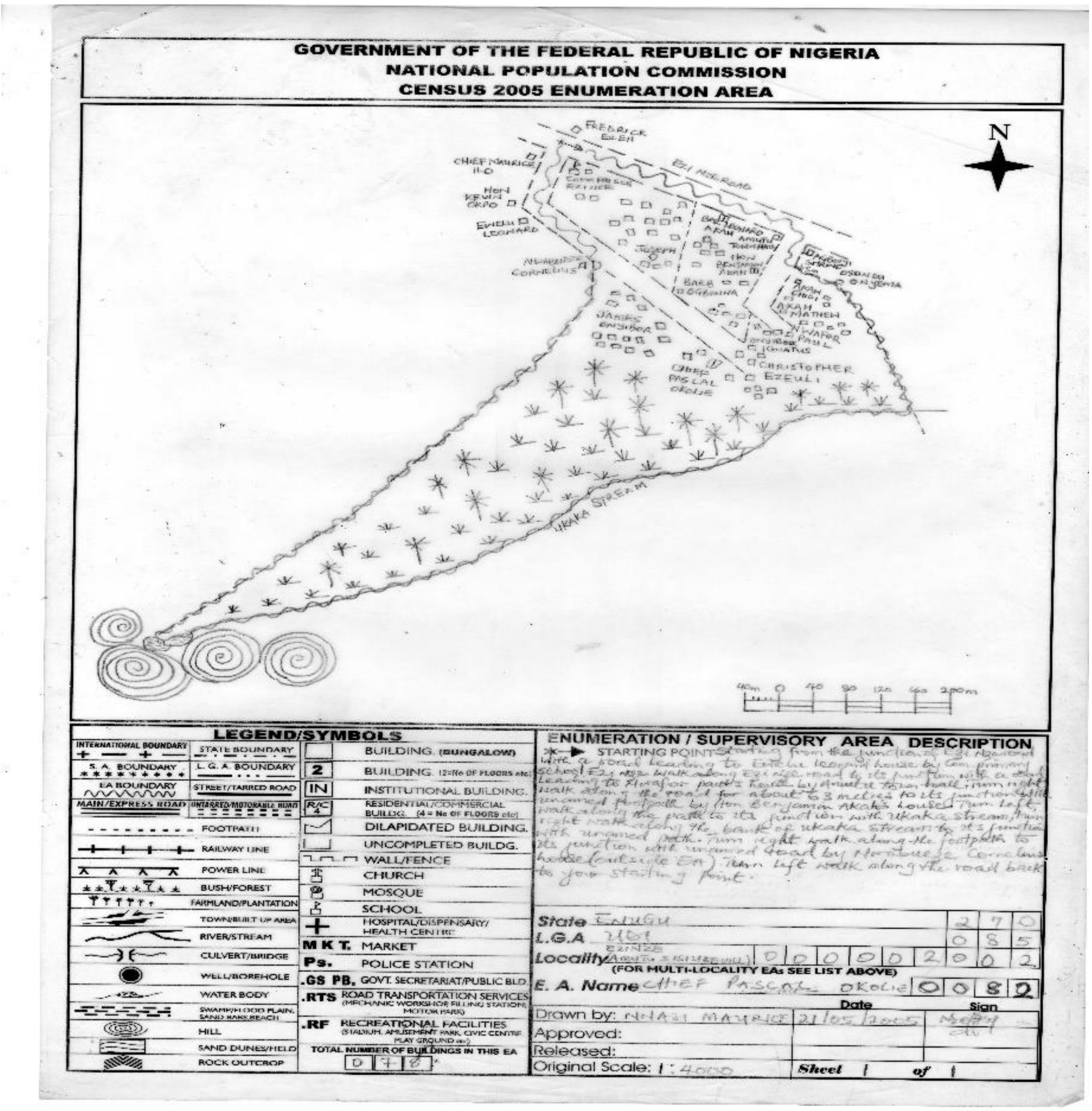


Figure 4.2. Cartographic representation of one of the rural EAs *(Source: National Population Commission, Nigeria)*

4.4.1. Sample frame

The list of enumeration areas in the state as given by the National Population Commission served as the sample frame.

4.4.2. Sample distribution

Allocation of clusters was 70% to the urban strata and 30% to the rural strata. This allocation was done in reverse proportion to actual population size to obtain a representative sample of the urban population, which is the primary population of interest. Furtherance to getting a representative sample of the urban population, the urban strata was subdivided into upper-class, middle-class and lower-class sub-strata. The classification of geographical areas in the urban strata into upper-class, middle-class and lower-class was based on observed clustering of residential house types and cost of rent. The upper-class areas have clustering of expensive houses that can be afforded by the rich within the population. These areas are Government Reserved Areas I and II (GRA I and GRA II) and Independence Layout areas. Cost of rent in these areas ranged from 600, 000 to 3, 000, 000 Naira per annum. Majority of people living in these areas are high-ranking medical practitioners, bankers, lawyers, political office holders, and big-time entrepreneurs. Majority of the houses in the upper-class area were owned by the occupants. The middle-class areas included New Haven, Trans-Ekulu, Ogui New Layout, Achara Layout, Uwani and Mary Land. Cost of house rent in these areas ranged from 200, 000 to 500, 000 Nigerian Naira per annum. Most people living in these areas are middle-level civil servants. The low-class areas are Iva Valley, Abakpa, Emene, Asata, Ogbete, Coal Camp, Obiagu and Gariki. Cost of rent for an average accommodation in these areas ranges from 50, 000 to 200, 000 Nigerian Naira per annum. Majority of people living in these areas are low-cadre civil servants and artisans. The areas within the urban substrata have definite geographical boundaries and defined population by the Nigerian National Population Commission.

Allocation of clusters to the different urban substrata was done proportionally to the official population figure of the areas that make up the substrata. Although the last national population census conducted in Nigeria was in 2006, the census has not been analysed to the community level. The census figures that have been analysed to the community level is the 1991 national census. Hence the 1991 census was used to project the population of areas for the year 2015, which was the year if the commencement of the field data collection. Using the 1991 census figures, population projections were made to 2015 with the formula: $\mathbf{Pt = Po\ e^{rt}}$

Pt = Population at present (2015)

Po = Population at an old reference point (1991)

e = Exponential

r = Population growth rate (3% [0.03] for Enugu State of Nigeria as obtained from the National Population Commission)

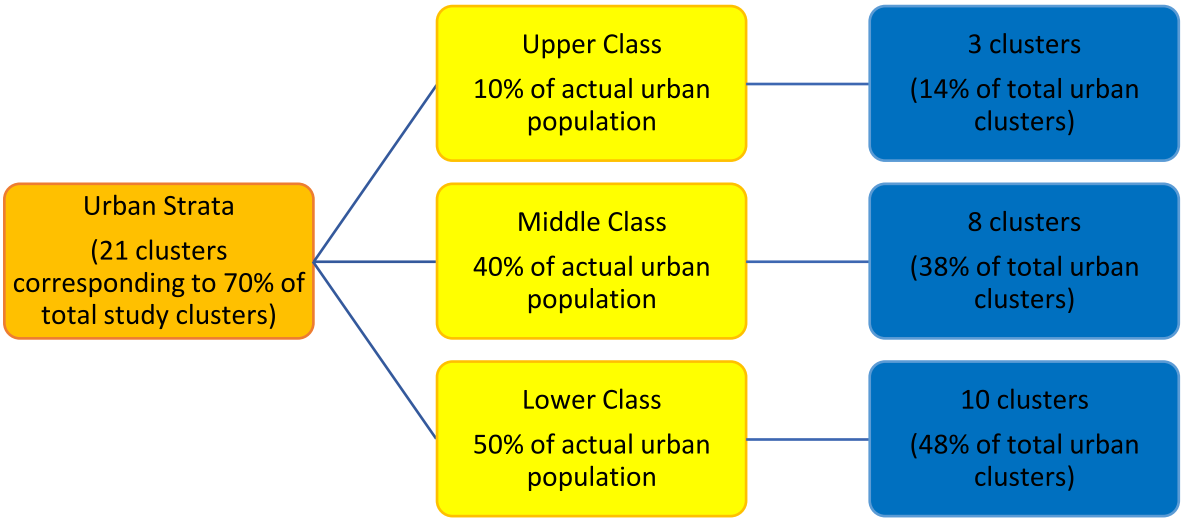
t = time frame in years (24 years [1991 – 2015])

Table 4.1 shows the projected populations of the areas.

The projected population of the urban strata for the year 2015 was 831840 with a distribution of approximately 10% in the upper-class substrata, 40% in the middle-class substrata and 50% in the lower-class substrata. The allocation of the clusters for sampling followed similar distribution proportional to population sizes. The upper-class substrata were allocated three clusters corresponding to 14% of the urban clusters. The middle-class substrata were allocated eight clusters corresponding to 38% of the urban of clusters and the lower-class substrata were allocated ten clusters corresponding to 48% of the urban clusters (Figure 4.3). A unique population of interest, individuals living within the university staff residential areas was considered necessary in this study and were hence allocated a cluster. The University community was not captured as a separate entity in the 1991 National population census. Hence all households within the university community were surveyed.

Table 4.1. Initial allocation of clusters based on projected population

Serial No.	Type of Locality	Name of Locality	1991 Census Population	2015 population Projection	Number of clusters allocated
1	Upper Class	GRA	19, 600	40266	2
2	Upper Class	Independence Layout	10, 036	20618	1
3	Middle Class	New Haven	18, 753	38527	1
4	Middle Class	Ogui New Layout	41, 237	84719	2
5	Middle Class	Trans-Ekulu	11, 474	23572	1
6	Middle Class	Achara Layout	50, 248	103231	2
7	Middle Class	Uwani	31, 875	65485	1
8	Middle Class	Mary Land	4, 666	9586	1
9	Lower Class	Iva valley	8, 891	18266	1
10	Lower Class	Asata	21, 828	44844	1
11	Lower Class	Ogbete	25, 994	53403	1
12	Lower Class	Emene	44, 531	91485	2
13	Lower Class	Abakpa	90, 619	186171	3
14	Lower Class	Obiagu	5, 487	11273	1
15	Lower Class	Gariki	19, 662	40394	1
16	University Community	UNEC	??	??	Entire Households sampled.
17	Rural	Awgu	136625	280687	1
18	Rural	Igbo-Etiti	138401	284335	1
19	Rural	Isi-Uzo	85716	176098	1
20	Rural	Udenu	111649	229375	1
21	Rural	Nkanu East	153591	315542	1
22	Rural	Ezeagu	112754	231646	1
23	Rural	Nsukka	220411	452819	1
24	Rural	Udi	238305	489582	1
25	Rural	Aninri	95620	196445	1



Total number of clusters allocated to urban strata

Actual population distribution in the urban strata

Clusters allocated to the sub-strata that make up the urban strata proportional to actual population distribution

Figure 4.3. Allocation of urban clusters proportional to population

4.4.3. Cluster definition

The enumeration areas served as clusters for this study. Each EA consists of a cluster approximately 54 households situated within the same location. The expected number of people per household was 4, thus giving an expected population of 216 per EA. Each EA has well-defined geographical boundaries, and the households within each EA are also well defined.

4.5. Data collection

4.5.1. Data collection questionnaire

A structured, interviewer-administered questionnaire comprising 49 questions was used to collect the data (Annex 6). The questionnaire was an adaptation of the Global School Health Survey (GSHS) questionnaire. The modules in the questionnaire are demographics, socio-economics, dietary, physical activity, and psychology. The modules were based on the risk factors of interest identified in the literature review.

Figure 4.4 shows the questionnaire modules illustrating the data the groups of data that were collected.

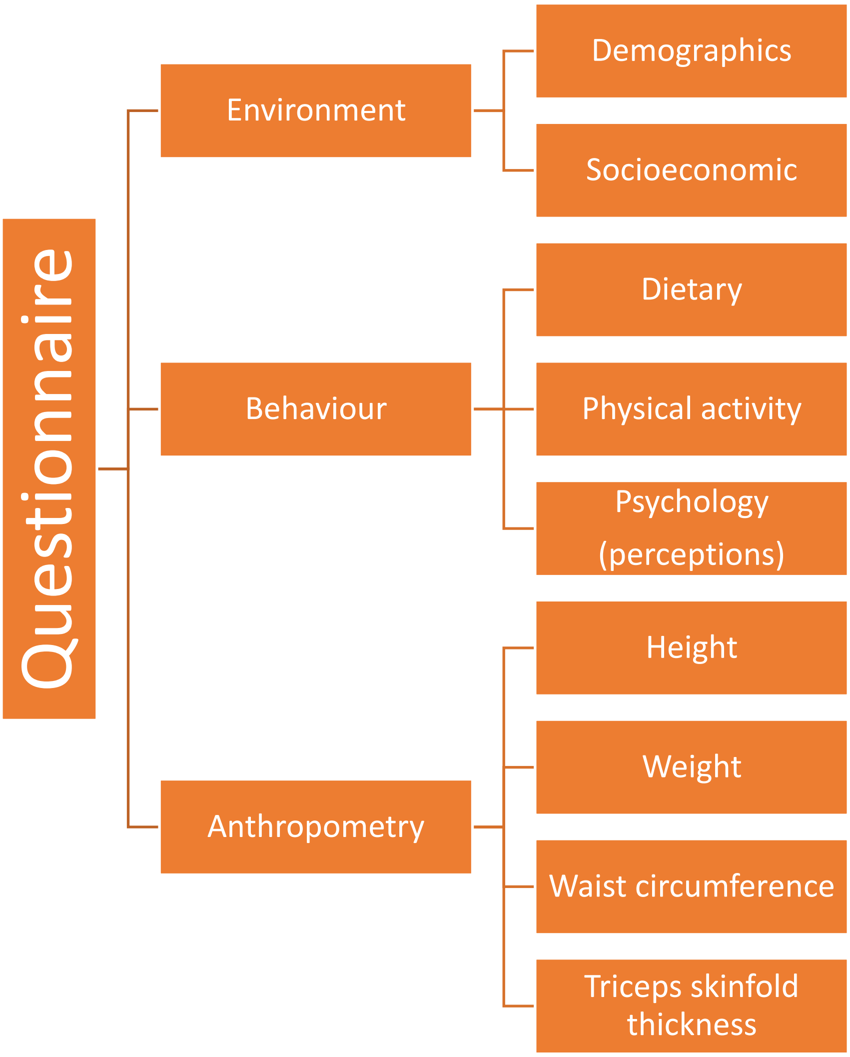


Figure 4.4. Questionnaire modules

4.5.2. Training of data collectors

The data collectors underwent 2-day intensive training on the data collection process. The training was conducted by the PhD candidate and experts from Women for Women International. The Women for Women International is a global organisation with several years of house to house data collection experience. The training module included the rationale for the study, study objectives, informed consent procedure, questionnaire content and administration, data entry into the questionnaires and anthropometric measurement. The training was very interactive and included several simulation sessions. The National Health and Nutrition Examination Survey (NHANES) anthropometry procedure manual was used for training in anthropometric measurements[228]. The hands-on part of the training took place during the pilot study, which was also supervised by the PhD candidate and the experts from Women for Women International.

4.5.3. Ethical approval and informed consent administration

The study protocol was reviewed and approved by the ethical committees of both, the University of Nigeria Teaching Hospital, Enugu Nigeria and the Ludwig-Maximilians-Universität Munich, Germany. A written informed consent translated was administered to each participant. Prior to recruitment, the data collectors carefully explained the objectives, rationale and the procedure for the data collection, as well as the use of the data, the voluntary nature of the study and rights of refusal to participate without recrimination to all participants. This consent was given in English language for individuals who were educated and opted to receive the information in English language. Participants who opted to receive the information in the local language received theirs in Igbo language. Participants were also given a written version of the consent information to peruse before appending their signatures or thumbprints for participation, as appropriate. The written version of the informed consent information was available in both English language and the local Igbo language.

4.5.4. Pilot study

The pilot study was conducted to evaluate the feasibility of the research and identify potential challenges to the field data collection namely: household and individual response rates, difficulties in questionnaire administration, measurements, data entry and data analysis. Budget management and optimal use of trained data collectors were also evaluated during the pilot study. Two urban streets and one rural community were randomly-selected for the pilot study.

The sample frame was a list of streets in the city centre and a list of communities in the rural areas in Enugu state. These communities were not part of the main study. Thirty households were listed for the pilot study, 18 households from the city centre and 12 households from the rural areas.

All consenting individuals aged between 20 and 60 years found within the households were interviewed and measured. All households located within the selected streets/community were sampled. The team comprised 3 data collectors per team. The duration of the pilot study was two days.

4.5.5. Pilot Study Challenges and Modifications

Important challenges that were encountered in the pilot study were:

- A large number of absentee household members, especially the males, at the time of household visitation. The pilot study visitations time stretched from 9 am to 2 pm. During this time, it was observed that many of the household members were not present.
- Difficulties in gaining the trust of the household members regarding the veracity of the aims of the visit. It was a difficult task convincing the households on the objectives of the study. Most households felt the survey was for tax purposes and other government-related issues.
- Redundancy of one team member during the data collection

Some modifications were made based on the lessons learned from the pilot study. These include:

- The timing of household visitations was changed to noon to 6 pm.
- Absentee forms were developed to record the number of absentees in a household for re-visit purposes. Each household with absentee members was revisited twice to capture the absentees.
- Data collectors were made to wear customized T-shirts branded with CIH/LMU/UNN logos to increase their visibility and acceptance by the households.
- Data collectors were also made to wear customised personal identification cards on their neck to increase their visibility and acceptance by the households.
- The composition of the data collection team was reduced to two data collectors per team.

4.5.6. Administration of Questionnaires

The questionnaires were administered by the data collectors. The questions and response options were read out to the participants in English language, Pidgin English language or Igbo language as appropriate (based on the educational level and choice of participant). The data collectors entered the responses of the participants into the questionnaire. The questionnaires are checked for completeness at the end of the interview session.

Anthropometric measurement follows the oral interviews. The height, weight, waist circumference and triceps skinfold thickness of the participant are measured per protocol. Details of the anthropometric measurements are given in subsequent sections (4.5.7, 4.5.8, 4.5.9, and 4.5.10).

4.5.7. Height measurement

The standing height is measured using a portable stadiometer with a standing platform, fixed vertical measuring frame and adjustable headpiece (Seca 213, Hamburg Germany). Figure 4.5 is a picture of the stadiometer.

The participants stand bare feet on the standing platform with his or her back erect on the measuring frame, heels together, and arms by the side. The back of the heels, buttocks shoulder blade and head make contact with the measuring frame whenever possible and depending on the overall body configuration of the participant. The head is then placed in the Frankfort horizontal plane. The Frankfort horizontal plane is “when the horizontal line from the ear canal to the lower border of the orbit of the eye is parallel to the floor and perpendicular to the vertical measuring frame”[229]. The stadiometer headpiece is then lowered to rest firmly on the participant’s head with sufficient pressure to compress the hair. Next, the participant is instructed to take a deep breath and hold the position while the data collector reads off the height. The manoeuvre of taking a breath and holding it serves to straighten the spine. This enables a more consistent and reproducible measurement[229]. Measurements were taken to the nearest millimetre (1mm).

Figure 4.5. Seca stadiometer model 213

4.5.8. Weight measurement

The weight was measured using an analogue weight scale with participants in light clothing and measurements taken to the nearest kg (1kg).

4.5.9. Waist circumference measurement

A measuring tape was used to measure the waist circumference. The participant is instructed to "raise his/her shirt/blouse a little above the waist, cross the arms and place the hands on opposite shoulders"[228]. The first data collector identifies the upper border of the right ileum and makes a horizontal line with a marker. Tracing an imaginary vertical line from the mid-axilla down to the horizontal line, a vertical mark is made to cross the horizontal line at 90 degrees as shown in figure 4.6. The measuring tape is placed with the zero end at the mark and held there by the first data collector. The second data collector takes the opposite end of tape around the participant's waist to the starting point and ensures that the tape is horizontal and parallel to the floor, and snug on the body but not compressing the skin. The measurement is taken to the nearest 0.1 cm.

Figure 4.6. Skin marking for waist circumference measurement *(source: National Health and Nutrition Examination Survey Anthropometry Procedures Manual)*

4.5.10. Triceps skinfold thickness measurement.

The triceps skinfold thickness was measured with a skinfold calliper (AK Sports). The skin of the posterior upper right arm of the participant is marked with a marker at the midpoint between the elbow and the shoulder. The skin is then grasped between the thumb and the index finger of the data collector and calliper placed perpendicular to the skin. The measurement is to the nearest 1 mm.

4.5.11. Absenteeism

Repeated visits up to a maximum of three times were made to households where one or more eligible individual was absent at the time of the first visit.

4.5.12. Quality control of data collection

Anthropometric measurements were repeated on a randomly-selected 5 % of the sample per day by a quality control team. If the disparity (> 0.5cm difference for height and > 0.1kg difference for weight) is found in more than 10% of subjects measured in the day, all subjects for that day were re-measured.

4.6. Data Entry

Double data entry was done by two independent data entry clerks for quality assurance purposes. The data was entered into SPSS software version 15.

4.7. Data Cleaning

Data cleaning was done using inbuilt SPSS functions. First, the SPSS 'analyse' function was used to run a quick frequency analysis of all the variables to identify impossible values and missing data. After that, the actual cases that contained the impossible value were identified using the 'select cases' function and finally running a second frequency analysis but using the serial number as the variables. Next, the subject identifiers of the cases with an impossible number were noted, and the questionnaire containing the raw data was identified and the mistakes corrected. Then, a quality assurance frequency analysis was done to confirm that the impossible values no longer existed. This process was repeated for each variable.

The 'identify duplicate' function of the SPSS was used to identify duplicate cases and the duplicate cases deleted.

4.8. Description of Variables

The variables are as follows:

Age: this describes the age in years of the respondent as the last birthday.

Age group: this describes the age group of the respondent categorised into two namely (1) younger adult aged 40 years and below (20-40 years), and (2) older adult aged above 40 years of age (41-60 years).

Gender: this describes the sex of the respondent categorized as (1) male and (2) female

Residence: this describes the area where the respondent lives categorised as (1) urban and (2) rural

Urban class: this describes the area where an urban residence lives within the urban area categorised as (1) upper-class (2) middle-class (3) lower-class and (4) university community

Marital status: this describes the marital status of the respondent categorised as (1) single (2) married (3) divorced (4) separated and (5) widowed.

Migration status: this describes whether the respondent is an indigene of Enugu state or an indigene of another state in Nigeria but living in Enugu state. This is categorised as (1) indigene of Enugu state (2) indigene of another state in Nigeria and (3) non-Nigerian

Ethnicity: this describes the ethnic group or tribe of the respondent and categorised as (1) Igbo (2) Hausa (3) Yoruba and (4) other ethnicity or tribe

Education: this describes the educational status of the respondent categorised as (1) no formal education (2) attended only the primary level of education (3) attended up to the secondary level of education (4) attended up to the post-secondary vocational education and (5) attended up to the university level of education. The education of the respondents was also classified as (1) those who did not have a university education and (2) those who had a university education.

Years of education: this describes the cumulative number of years of education of the respondent up to a maximum of 16 years (16 years is the minimum number of years of education of a university graduate).

Income class: this describes the income class of the respondents based on the average monthly income of the respondent. This was categorised as (1) low-income class for those who earn less than 36 000 Nigerian Naira (2) middle-income class for those who make from 36 000 to 180 000 Nigerian Naira and (3) upper-income class for those who earn more than 180 000 Nigerian Naira. This classification was based on an adaptation of income classification by the African Development Bank[230].

Perception of own body size: this describes the way the respondent perceives his or her own body size categorised as (1) perceives own body size as underweight (2) perceives own body size as normal size (3) perceives own body size as overweight/obese.

Perception of large body size: this describes how the respondent perceives people with large body size categorised as (1) perceives people with large body size as having a negative, unhealthy or undesirable attribute (2) perceives people with large body size as having a positive, healthy or desirable attribute and (3) had neither negative nor positive perception of people with large body size.

Weight management behaviour: this describes the actions being taken by the respondent on his or her weight categorised as (1) doing nothing about his or her weight (2) taking actions to lose weight (3) taking actions to gain weight and (4) taking actions to remain the same weight

Physical activity: this describes the physical activity level of the respondent categorised into (1) physically inactive and (2) physically active. Those classified as physically active are those who spend up to 150 minutes per week in moderate or vigorous physical exercises while those that spend fewer than 150 minutes per week in moderate or vigorous physical exercises are classified as physically inactive. This classification is based on the World Health Organisation definition of physical inactivity.

Outdoor leisure time physical exercise: this describes the number of days in a week that respondent undertakes an outdoor leisure time physical exercise. This was categorised as (1) do not undertake any outdoor leisure time physical exercise and (2) at least once a week outdoor leisure time physical exercise.

Hindrances to outdoor leisure time physical inactivity: this describes the reported hindrances to outdoor leisure time physical exercise. The respondents were allowed only one option, the most important hindrance. The hindrances were lack of time, fear of criminals, fear of traffic, indoor exercises, lack of interest, disability, ill-health and no hindrance.

Full meal intake: this describes how often the respondent takes a full meal per day categorised as (1) less than 3 full meals per day and (2) 3 or more full meals per day

Carbonated drink intake: this describes whether a respondent takes carbonated sweet drinks daily or not, categorised as (1) no daily carbonated drinks intake in the past 30 days and (2) daily carbonated drinks in the past 30 days.

Fruit intake: this describes whether a respondent takes fruits daily or not, categorised as (1) no daily fruit intake in the past 30 days and (2) daily fruit intake in the past 30 days

4.9. Data Analysis

The data were analysed using SPSS version 15.0. All tests were performed at a 5% significance level. Body weight was classified into three categories, according to the WHO body mass index (BMI) classification[4].

4.9.1. Descriptive Statistics

Continuous variables were reported as mean with two standard deviations while categorical variables were reported in proportions using percentages. The overall mean BMI was weighted. Comparison between groups weighted mean BMI was done using the independent sample t-test. The mean waist circumference and mean Triceps skinfold thickness were calculated and reported with two standard deviations.

4.9.2. Prevalence Estimation

All prevalence and their confidence intervals were estimated using weighted estimates, taking the population distributions in the different strata into account. Z-test was used to compare the weighted prevalence of obesity and overweight between relevant population sub-groups namely: men and women, urban and rural residents, younger and older adults (≤40 years of age and >40 years of age).

4.9.3. Waist circumference and BMI

Pearman's correlation statistics were used to compare the linear relationship between the waist circumference (WC) and the BMI. The t-test for independent samples was used to compare the mean WC in males with the mean WC in females. Sensitivity and specificity of the WC in predicting obesity were evaluated using Receiver Operating Curve (ROC) analysis. The WC value where the highest level of sensitivity meets the highest level of specificity was taken to be the cut-off point for WC, using the Youden Index. Values of WC above this cut-off point were taken to represent the obese state while values of WC below this cut-off point were taken to represent the non-obese state. The ROC analyses were done separately for males and females.

4.9.4. Triceps skinfold thickness and BMI

Pearman's correlation statistics were used to compare the linear relationship between the Triceps skinfold thickness (TSKFT) and the BMI. The mean TSKFT in males was compared with that in females using the t-test for two independent samples. Sensitivity and specificity of the TSKFT in predicting obesity were evaluated using Receiver Operating Curve (ROC) analysis. The TSKFT value where the highest level of sensitivity meets the highest level of specificity was taken to be the cut-off point for TSKFT, using the Youden Index. Values of TSKFT above this cut-off point were taken to represent the obese state while values of TSKFT below this cut-off point were taken to represent the non-obese state. The ROC analyses were done separately for males and females.

4.9.5. Sociodemographic correlates of obesity and overweight.

Multinomial regression analysis was done to determine the socio-demographic correlates of overweight and obesity reporting adjusted odds ratios (AOR) together with 95% confidence intervals and p-values of the Wald test. The dependent categories were underweight, normal weight, overweight and obese. The reference category was normal weight. The predicting variables were the age in years, gender, urban/rural residence, income class, and education.

4.9.6. Behavioural risk factors for obesity and overweight: physical activity

The proportions of the population that are physically active and inactive were estimated using weighted estimates, taking the population distributions in the different strata into account. Z-tests were employed to compare the weighted prevalence of physical inactivity between relevant population sub-groups namely: males and females, urban and rural residents, younger and older adults (≤40 years of age and >40 years of age). Z-test was also used to compare the weighted proportion of physically active persons who were obese and that of physically inactive persons who were obese. Binary logistic regression was used to evaluate the determinants of physical activity with the response variable as physically active or inactive. The predicting variables were the age in years, gender, urban/rural residence, income class and education.

Multinomial regression was used to evaluate the effect of physical activity on obesity and overweight. The dependent variable was BMI category of underweight, normal, overweight and obese with normal weight as the response category. The independent variable was being physically active or not, while age and gender were confounding variables. In both the binary and multinomial logistic regressions, adjusted odds ratios (AOR) together with 95% confidence intervals and p-values of the Wald test were reported.

The proportions of the population that reported at least once a week outdoor leisure time physical exercise were weighted, taking the population distributions in the different strata into account. The weighted proportions were compared between relevant population sub-groups namely: males and females, urban and rural residents, younger and older adults (≤40 years of age and >40 years of age) using z-tests. Binary logistic regression was also used to evaluate the predictors of outdoor leisure time physical exercise with the response variable as no outdoor leisure time physical exercise or at least once a week outdoor leisure time physical exercise. The predicting variables were age, gender, urban/rural residence, income class and education. Adjusted odds ratios (AOR) together with 95% confidence intervals and p-values of the Wald test were reported.

The reported hindrances to outdoor leisure time physical exercise were compared between urban and rural residents using Chi-square tests.

4.9.7. Behavioural risk factors for obesity and overweight: dietary factors

The proportion of the overall population that had up to 3 full meals per day was weighted taking the population distributions in the different strata into account. The weighted proportion of obese persons who reported having up to 3 full meals per day were compared with the weighted proportion of non-obese persons who reported having up to 3 full meals per day using z-test.

The proportion of the overall population who did not eat fruits daily in the past 30 days was weighted taking the population distributions in the different strata into account. The weighted proportion of obese persons who reported not eating fruits daily in the past 30 days were compared with the weighted proportion of non-obese persons who reported not eating fruits daily in the past 30 days using z-test.

The proportion of the overall population who reported drinking carbonated sweet drinks daily in the past 30 days was weighted taking the population distributions in the different strata into account. The weighted proportion of obese persons who reported drinking carbonated sweet drinks daily in the past 30 days were compared with the weighted proportion of non-obese persons who reported drinking carbonated sweet drinks daily in the past 30 days using z-test.

4.9.8. Perceptions of large body size and obesity

The distribution of the population according to the perception of large body size was estimated with weights taking into consideration, the population distributions in the different strata. Binary logistic regression was carried out to determine the effect of respondents' perception of large body size on the measured BMI with being obese or not as the binary dependent variable and perception of large body mass as the predictor variable. Confounding variables were age, sex, education, employment status, income class and urban/rural residence. Adjusted odds ratios (AOR) together with 95% confidence intervals and p-values of the Wald test were reported

4.9.9. Perceptions of own body size and obesity

The distribution of the obese persons according to the perception of own body size was estimated with weights taking into account the population distributions in the different strata. Agreement between respondents' perceived own body size and measured BMI category was evaluated with Kappa statistics. Multinomial logistic regression was done to evaluate the relationship between perception of own body size and weight management behaviour of respondents. The dependent variable was weight management behaviour categories of do nothing about weight, lose weight, gain weight and stay same weight; with do nothing about weight as the reference category. The predictor variable was the perception of own body size and confounders were age, gender and urban/rural residence. Adjusted odds ratios (AOR) together with 95% confidence intervals and p-values of the Wald test were reported

CHAPTER 5

5. Results

5.1. Results of Pilot Study

The results from the pilot study showed that it was feasible to attain the calculated sample size within the allocated time frame. The results also gave a good insight into the average number of adults per household, and the average response and decline rates.

5.1.1. Participation

A total of 30 households were selected for the pilot study. One household declined participation giving a response rate of 96.7% for households. One individual out of the 80 adults met in the consenting 29 households declined participation giving a response rate of 98.8% for individuals, and an average of 2.8 adults per household. There were 25 (31.6%) males and 54(68.4%) females. Fifty-three of the respondents were from the urban area while 26 were from the rural area.

5.1.2. Prevalence of Obesity

A total of 1(1.3%) participant was underweight, 34(43.0%) participants had normal weight, 19(24.1%) participants were overweight, and 25(31.6%) participants were obese. More men 7(28.0%) were overweight than women 12(22.2%). However, more women 22(40.7%) were obese than men 3(12.0%). The only underweight participant was male. Table 5.1 shows the distribution of the weight classification by the gender of participants.

Table 5.1. Weight classification by gender (Pilot study)

			Weight Class				Total
			Under-weight	**Normal Weight**	**Over-weight**	**Obese**	**Total**
Sex	Male	Number	1	14	7	3	25
		% within Sex	4.0%	56.0%	28.0%	12.0%	100.0%
		% of Total	1.3%	17.7%	8.9%	3.8%	31.6%
	Female	Number	0	20	12	22	54
		% within Sex	.0%	37.0%	22.2%	40.7%	100.0%
		% of Total	.0%	25.3%	15.2%	27.8%	68.4%
Total		Number	1	34	19	25	79
		% of Total	1.3%	43.0%	24.1%	31.6%	100.0%

5.1.3. Obesity and perception of body size

Six (24%) obese persons perceived their body size as underweight, 9(36%) obese person perceived the body size as normal size, while 10(40%) obese persons perceive their body size as obese/overweight. This is shown in figure 5.1.

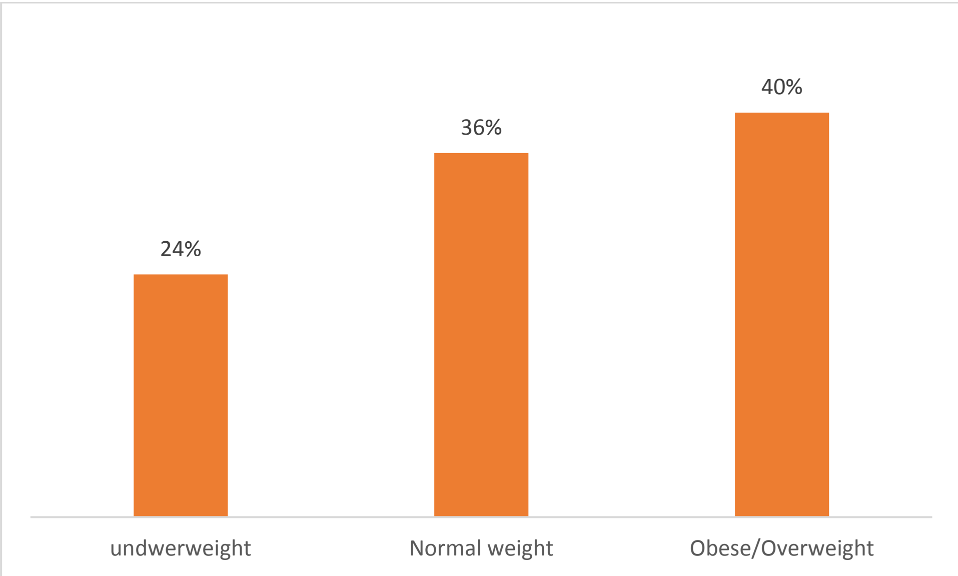


Figure 5.1. How obese people perceive their body size (pilot study)

5.2. Main Study Results

5.2.1. Sociodemographic characteristics of respondents

Sixty-five enumeration areas and one university community were sampled out of 13 998 EAs in Enugu State. The sampled EAs were in 12 out of the 17 Local Government Areas (LGA) of the state. The LGAs included all three urban LGAs of the city of Enugu and nine out of the 14 rural LGAs in the state. A total of 6683 individuals were interviewed and measured. A total of 55 cases (53 who were pregnant and 2 with missing anthropometrics data) were excluded from the final analyses, leaving 6628 for analysis. According to the sampling scheme, 69.9% (n=4630) participants were from the urban area, while 30.1% (n=1998) were from the rural area. Nearly 60% of the participants were females (n=3876) and mean age was 34.9 years (± 13.2 years standard deviation). About 66.1% (n=4380) were aged 40 and below while 33.9% (n=2248) were aged above 40 years. Nearly 51% (n=3374) participants were single, 45.9% (n=3041) were married, 0.3% (n=23) were divorced, 0.3% (n=22) were separated and 2.5% (n=168) were widowed. According to ethnicity, 95.2% (n=6310) participants were of Igbo ethnicity, 2.1% (n=137) were of Hausa ethnicity, 0.8% (n=51) were of Yoruba ethnicities and 2.0% (n=130) were of other ethnicities. Table 5.2 shows the demographic characteristics of the participants while Table 5.3 shows the socio-economic characteristics.

Table 5.2. Demographic characteristics of respondents

Characteristic	Number	Percentage (%)
Gender		
Female	3876	58.5
Male	2752	41.5
Age in years		
≤ 40	4380	66.1
>40	2248	33.9
Residence		
Urban	4630	69.9
Rural	1998	30.1
Urban class		
Upper	644	9.7
Middle	1745	26.3
Lower	2187	33.0
University	53	0.8
Ethnicity		
Igbo	6310	95.2
Hausa	137	2.1
Yoruba	51	0.8
Others	130	2.0
Migration status		
Indigene of Enugu	4560	68.8
Indigene of another state	2064	31.1
Non-Nigerian	4	0.1

Table 5.3. Socioeconomic characteristics of respondents

Characteristic	Number	Percentage (%)
Marital status		
Single	3374	50.9
Married	3041	45.9
Divorced	22	0.3
Separated	23	0.3
Widowed	168	2.5
Education		
No education	127	1.9
Primary education	1212	18.3
Secondary education	3961	59.8
Post-secondary vocational education	180	2.7
University education	1146	17.3
Income Class		
No income	2246	33.9
Low-income class	3113	46.9
Middle-income class	624	9.4
High-income class	645	9.7

5.2.2. Body Mass Index

The weighted overall mean BMI for the population is 23.44 kg/m² (95% CI: 23.29 kg/m²-23.58 kg/m²). The weighted mean BMI for males is 22.84 kg/m² (95% CI: 22.66 kg/m²-23.03 kg/m²), while that for females is 23.84 kg/m² (95% CI: 23.63 kg/m²-24.04 kg/m²). The difference was statistically significant ($p < 0.001$). For the urban residents, the weighted mean BMI is 24.07 kg/m² (95% CI: 23.94 kg/m²-24.20 kg/m²). This was significantly higher than the weighted mean BMI of rural residents of 23.16 kg/m² (95% CI: 22.96 kg/m²-23.37 kg/m²), p = <0.001. Individuals aged 40 years and below had a weighted mean BMI of 23.17 kg/m² (95% CI: 22.97 kg/m²-23.36 kg/m²); while those aged above 40 years had a weighted mean BMI of 23.94 kg/m² (95% CI: 23.71 kg/m²-24.18 kg/m²). The difference was statistically significant, $p < 0.001$.

5.2.3. Prevalence of Obesity, overweight, normal weight and underweight

The weighted overall prevalence for underweight was 9.1% (95% CI: 8.1% - 10.1%), 65.1% (95% CI: 63.4% - 66.6%) for normal weight, 19.0% (95%CI: 17.8% - 20.3%) for overweight and 6.8% (95% CI: 6.0% - 7.5%) for obese. For males (n = 2752), 9.7% (95% CI: 8.1% - 11.3%) were underweight, 70% (95% CI: 67.8% - 72.3%) had normal weight, 17.0% (95% CI: 15.2% - 18.8%) were overweight and 3.2% (95% CI: 2.4% - 4.0%) were obese. For females 8.6% (95% CI: 7.4% - 9.9%) underweight, 61.7 (95% CI: 59.8% - 63.7%) had normal weight, 20.4 (95% CI: 18.8% - 22.1%) overweight and 9.2% (95% CI: 8.1% - 10.3%) were obese.

The prevalence of overweight among females was 20.4% (95% CI: 18.8% - 22.1%) and significantly higher compared to the prevalence among males of 17.0% (95% CI: 15.2% - 18.8%) with a p-value of $p=0.005$. Similarly, the prevalence of obesity was significantly higher in females (9.2%; 95% CI: 8.1% - 10.3%) than in males (3.2%, 95% CI: 2.4% - 4.0%), with a p-value of $p<0.001$.

Prevalence of overweight among the younger population aged 40 years or below was 18% (95% CI: 16.4%-19.6%) and was significantly lower than the older population aged above 40 years 20.8% (95% CI: 18.9%-22.7%, $p=0.027$). Also, the prevalence of obesity among younger individuals aged 40 years and below was significantly lower than that of older individuals aged above 40 years ($p<0.0001$), with 5.4% (95% CI: 4.5%-6.4%) versus 9.8% (95% CI: 8.5%-11.1%).

Among urban residents the prevalence of overweight and obesity were significantly higher compared to rural residents (24.7%, 95% CI: 23.5%-26.0% vs. 16.6%, 95% CI:15.0%-18.2%, $p<0.001$ for overweight; 9.8%, 95% CI: 8.9%-10.7% vs. 5.5%, 95% CI: 4.5%-6.5%, $p<0.001$ for obesity).

Within the urban strata, prevalence of overweight and obesity were 24.4% and 8.5%, respectively in the upper-class. The corresponding figures within the middle-class were 29.3% and 12.8%. In the lower-class prevalence of overweight and obesity were 21.4% and 7.7%. The corresponding figures in the university community were 37.7% and 18.9%, respectively. These are also shown in Table 5.4.

Table 5.4. Prevalence (in percent) and 95% CI according to BMI classification of weight (Prevalence are weighted sums over sample strata)

Population	Underweight	Normal weight	Overweight	Obese
Total population	9.1% (8.1%-10.1%)	65.1% (63.6%-66.6%)	19.0% (17.8%-20.3%)	6.8% (6.0%-7.5%)
Males	9.7% (8.1%-11.3%)	70.0% (67.8%-72.3%)	17.0% (15.2%-18.8%)	3.2% (2.4%-4.0%)
Females	8.6% (7.4%-9.9%)	61.7% (59.7%-63.7%)	20.4% (18.8%-22.1%)	9.2% (8.1%-10.3%)
Rural residents	10.7% (9.3%-12.1%)	67.2% (65.1%-69.2%)	16.6% (15.0%-18.2%)	5.5% (4.5%-6.5%)
Urban residents (total)	5.3% (4.6%-6.0%)	60.2% (58.7%-61.6%)	24.7% (23.5%-26.0%)	9.8% (8.9%-10.7%)
Urban upper class	2.3% (1.2%-3.5%)	64.8% (61.5%-68.4%)	24.4% (21.1%-27.7%)	8.5% (6.4%-10.7%)
Urban middle class	1.7% (1.1%-2.3%)	56.2% (53.8%-58.5%)	29.3% (27.2%-31.5%)	12.8% (11.3%-14.4%)
Urban lower class	8.4% (7.2%-9.5%)	62.5% (60.4%-64.5%)	21.4% (19.7%-23.2%)	7.7% (6.6%-8.8%)
Urban University community	0.0% (0.0%-0.0%)	43.4% (30.1%-56.7%)	37.7% (24.7%-50.8%)	18.9% (8.3%-29.4%)
≤ 40 years of age	9.3% (7.9%-10.6%)	67.3% (65.3%-69.3%)	18.0% (16.4%-19.6%)	5.4% (4.5%-6.4%)
> 40 years of age	8.9% (7.5%-10.4%)	60.5% (58.2%-62.8%)	20.8% (18.9%-22.7%)	9.8% (8.5%-11.1%)

5.2.4. Distribution of obese persons according to obesity class

The weighted proportion of obese persons who had class I obesity was 45.24%. Table 5.5 shows the distribution of obese persons according to class of obesity.

Table 5.5. Distribution of obese persons according to obesity class

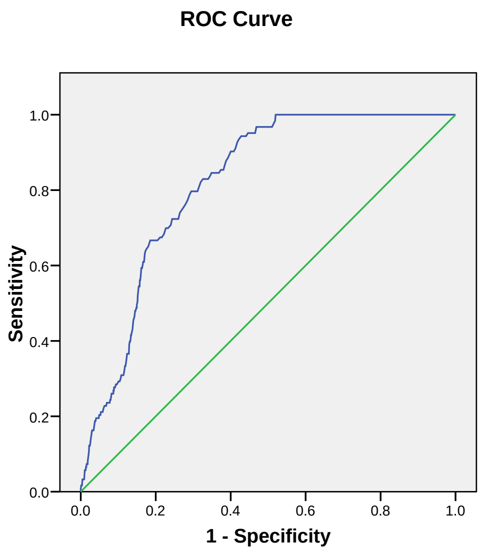
Class of obesity	Weighted prevalence within the obese class	95% Confidence Interval	
		Lower	Upper
Obese class I	45.24%	38.98%	51.50%
Obese class II	33.06%	26.60%	39.52%
Obese class II	21.70%	15.73%	27.67%

5.2.5. Waist circumference and BMI

The mean WC (unweighted) among male participants was 95.9 cm (± 12.7 Standard Deviation). There was a good correlation between the WC and BMI of males with Pearson's correlation coefficient of 0.71, p = <0.0001. The ROC analysis for the males showed the cut-off point for highest sensitivity and highest specificity at 102. 75 cm for obesity. The sensitivity and specificity at this cut-off point were 79.7% and 70.5% respectively (Youden Index = 0.50). The Area Under Curve (AUC) for males was 0.82 (95% CI: 0.79- 0.84). Figure 5.2 shows the ROC Curve for males.

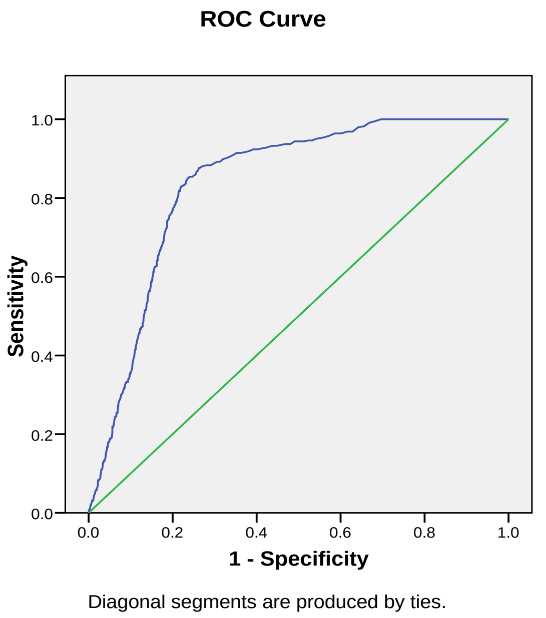
For female participants, the mean WC (unweighted) was 86.5 cm (± 10.1 Standard Deviation). Pearson's correlation coefficient between WC and BMI was 0.64, p = <0.0001. The ROC analysis for the females showed the cut-off point for highest specificity and sensitivity at 85. 35 cm for obesity, with a sensitivity of 84.9% and specificity of 76.5% (Youden Index = 0.61). The Area Under Curve (AUC) for females was 0.84 (95% CI: 0.82- 0.86). Figure 5.3 shows the ROC Curve for females. The mean WC (unweighted) of male participants was significantly higher than that of females, p=<0.0001.

Figure 5.2. ROC curve for males: waist circumference versus obesity



Diagonal segments are produced by ties.

Figure 5.3. ROC Curve for females: waist circumference versus obesity

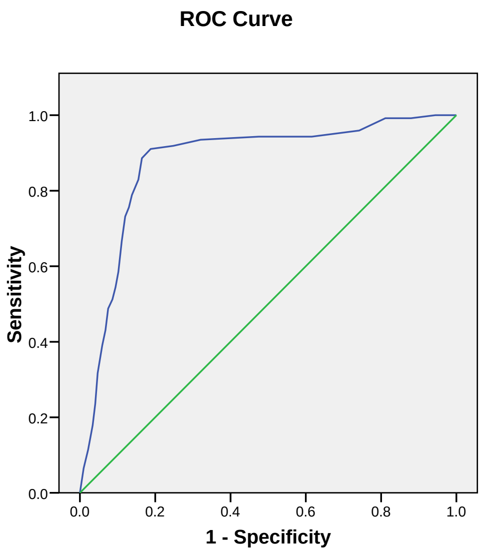


5.2.6. Triceps skinfold thickness and BMI

The unweighted mean TSKFT for male participants was 11.3cm (± 6.5cm standard deviation). The correlation of TSKFT with BMI was poor (Pearson's correlation coefficient = 0.39, p = <0.0001). The ROC cut-off point was 12.5 cm for obesity, with a sensitivity of 91.1% and specificity of 81.2% (Youden Index = 0.70). The Area Under Curve of the ROC was 0.88 (95% CI: 0.84-0.91). Figure 5.4 shows the ROC curve for TSKFT for males.

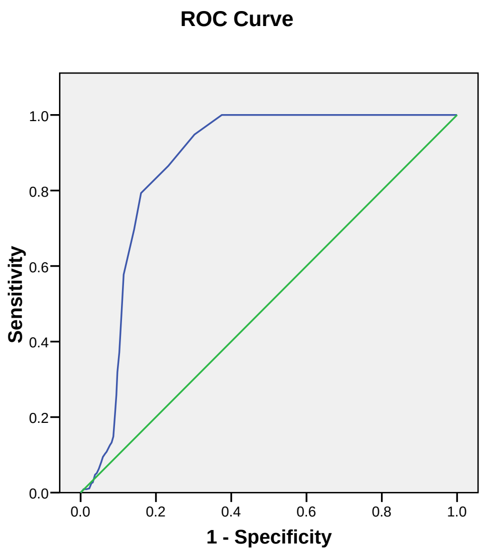
The unweighted mean TSKFT for female participants was 24.5 cm (±8.3 cm standard deviation). The Pearson's correlation coefficient was 0.57, p = <0.001. The ROC cut-off point for obesity was 26.5 cm. This cut-off point has a sensitivity of 86.5% and a specificity of 76.7% (Youden Index = 0.63). The Area Under Curve of the ROC was 0.87 (95% CI: 0.85-0.88). Figure 5.5 shows the ROC curve for TSKFT for females. The mean TSKFT was significantly higher in female participants than males (p=<0.0001)

Figure 5.4. ROC curve for TSKFT for males



Diagonal segments are produced by ties.

Figure 5.5. ROC for TSKFT for females



Diagonal segments are produced by ties.

5.2.7. Socio-demographic Determinants of Obesity and overweight

Significant predictive factors for obesity were age, gender, residence (urban/rural), and income class. Urban dwellers are 2.1 times more likely to be obese than rural dwellers (AOR: 2.087; 95% CI: 1.577-2.764). Males are less likely to be obese than females (AOR: 0.243; 95% CI: 0.189-0.312). Compared to the high-income class, individuals in the low-income class are less likely to be obese (AOR: 0.436; 95% CI: 0.284-0.670). The middle-income class were also less likely to be obese compared to the high-income class, but the difference did not reach statistical significance (AOR: 0.761; 95% CI: 0.532-1.089). The risk of obesity increases by a factor of 1.03 for each additional 1-year increase in age between 20 and 60 years of age (AOR: 1.031; 95% CI: 1.021-1.040). Education did not show an additional, independent, significant impact on the risk of obesity.

Age, gender and residence (urban/rural) were significant predictors of overweight in all the models. These remained significant after adjusting for education and income class. Individuals living in urban areas are 1.4 times more likely to be overweight than those in rural areas (AOR: 1.421; 95% CI: 1.183-1.707). Males are significantly less likely to be overweight compared to females (AOR: 0.786; 95% CI: 0.675-0.915). For each additional 1-year increase in age between 20 and 60 years of age, the risk of overweight increases by a factor of 1.012 (AOR: 1.012; 95%CI: 1.005-1.018). Compared to the high-income class, the low-income class are less likely to be overweight (AOR: 0.694; 95% CI: 0.507-0.951). Education did not show a significant independent impact on the risk of overweight. These are shown in Table 5.6.

Sub-group analysis of the urban strata showed that age, gender, class of area of residence and income class had significant impacts on the risk of obesity. Only education did not have a significant impact on the risk of obesity among the urban residents. Male gender significantly reduced the risk of obesity when compared to the female gender (AOR: 0.251; 95% CI: 0.189-0.334). Age and class of area of residence had significant impacts on the risk of overweight among the urban residents. Gender, income class and education did not have significant impact on the risk of overweight in the best model. These are shown in Table 5.7.

In the rural sub-group analysis, only gender predicted the risk of overweight and obesity. Males were less likely to be obese (AOR: 0.223; 95% CI: 0.125-0.400) and less likely to be overweight (AOR: 0.702: 95% CI: 0.530-0.929) when compared to females. Age, education and income did not show a significant impact on the risk of overweight or obesity in the rural population. These results are shown in Table 5.8.

Table 5.6. Sociodemographic predictors of overweight and obesity (Multinomial Regression)

Weight category [a]	Predictor	AOR	95% Confidence Interval		p-value
			Upper	Lower	
Obese	Age in years	1.031*	1.021	1.040	<0.001
	Male gender	0.243*	0.189	0.312	<0.001
	Female gender	.	.	.	.
	Urban residence	2.087*	1.577	2.764	<0.001
	Rural residence	.	.	.	.
	Low-income class	0.436*	0.284	0.670	<0.001
	Middle-income class	0.761	0.532	1.089	0.135
	High-income class	.	.	.	.
	University education	0.867	0.607	1.238	0.432
	No university education	.	.	.	.
Overweight	Age in years	1.012*	1.005	1.018	<0.001
	Male gender	0.786*	0.675	0.915	0.002
	Female gender	.	.	.	.
	Urban residence	1.421*	1.183	1.707	<0.001
	Rural residence	.	.	.	.
	Low-income class	0.694*	0.507	0.951	0.023
	Middle-income class	0.909	0.692	1.194	0.492
	High-income class	.	.	.	.
	University education	1.091	0.841	1.414	0.512
	No University education	.	.	.	
Underweight	Age in years	1.003	0.993	1.012	0.558
	Male gender	1.176	.928	1.491	0.180
	Female gender	.	.	.	.
	Urban residence	0.993	0.774	1.274	0.956
	Rural residence	.	.	.	.
	Low-income class	7.146*	1.953	26.154	0.003
	Middle-income class	1.382	0.335	5.696	0.655
	High-income class	.	.	.	.
	University education	0.292*	0.121	0.704	0.006

No University education	.	.	.	.

[a] Reference category = Normal weight

* Significant, i.e. $p < 0.05$

Abbreviations: AOR = Adjusted Odds Ratio

Table 5.7. Sociodemographic predictors of overweight and obesity among urban residents (Multinomial Regression)

Weight class [a]	Predictor	AOR	95% Confidence Interval		p-value
			Upper	Lower	
Obese	Age	1.043*	1.031	1.054	< 0.001
	Male gender	0.251*	0.189	0.334	< 0.001
	Female gender	.	.	.	.
	Upper-class	0.558*	0.348	0.893	0.015
	Middle-class	1.399*	1.026	1.907	0.034
	University community	1.446	0.513	4.074	0.485
	Lower-class	.	.	.	.
	Low-income class	0.480*	0.299	0.771	0.002
	Middle-income class	0.653*	0.443	0.963	0.031
	High-income class	.	.	.	.
	University education	0.967	0.669	1.399	0.859
	No university education	.	.	.	.
Overweight	Age	1.016*	1.009	1.024	< 0.001
	Male gender	0.839	0.698	1.008	0.061
	Female gender	.	.	.	.
	Upper-class	0.661*	0.475	0.921	0.014
	Middle-class	1.221	0.976	1.526	0.080
	University community	1.645	0.695	3.890	0.257
	Lower-class	.	.	.	.
	Low-income class	0.729	0.514	1.033	0.075
	Middle-income class	0.895	0.668	1.200	0.459
	High-income class	.	.	.	.
	University education	1.196	0.910	1.571	0.199
	No university education	.	.	.	.

Underweight	Age	1.016*	1.003	1.030	0.019
	Male gender	1.450*	1.035	2.031	0.031
	Female gender	.	.	.	.
	Upper-class	1.073	0.574	2.005	0.825
	Middle-class	0.469*	0.272	0.808	0.006
	University community [b]	2.26E-007	2.26E-007	2.26E-007	.
	Lower-class	.	.	.	.
	Low-income class	16.694*	1.963	141.992	0.010
	Middle-income class	2.446	.249	24.028	0.443
	High-income class	.	.	.	.
	University education	0.208*	0.059	0.737	0.015
	No university education	.	.	.	.

[a] Reference category = Normal weight

[b] No case of underweight was observed in the university community

* Significant, i.e. $p < 0.05$

Abbreviations: AOR = adjusted Odds Ratio

Table 5.8. Sociodemographic predictors of overweight and obesity among rural residents (Multinomial Regression)

BMI category [a]		AOR	95% Confidence Interval		p-value
			Upper	Lower	
Obese					
	Age	1.001	0.984	1.019	0.893
	Male gender	0.223*	0.125	0.400	< 0.001
	Female gender	.	.	.	.
	Low-income class	0.538	0.041	7.012	0.636
	High-income class	1.679	.166	16.939	0.660
	Middle-income class	.	.	.	.
	University education	0.774	0.172	3.477	0.738
	No university education	.	.	.	.
Overweight					
	Age	1.005	0.995	1.016	0.321
	Male gender	0.702*	0.530	0.929	0.013
	Female gender	.	.	.	.
	Low-income class	0.557	0.116	2.671	0.464
	High-income class	0.360	0.076	1.703	0.198
	Middle-income class	.	.	.	.
	University education	0.817	0.271	2.463	0.720
	No university education	.	.	.	.
Underweight					
	Age	0.989	0.976	1.002	0.107
	Male gender	0.929	0.657	1.313	0.677

	Female gender	.	.	.	.
	Low-income class	0.357	0.044	2.872	0.333
	High-income class	0.302	0.038	2.374	0.255
	Middle-income class	.	.	.	.
	University education	0.520	0.112	2.421	0.405
	No university education	.	.	.	.

[a] Reference category = normal weight

* Significant, i.e. $p < 0.05$

Abbreviations: AOR = Adjusted Odds Ratio

5.2.8. Behavioural risk factors for obesity and overweight: physical activity

The overall weighted prevalence of physical activity was 67.32% (95% CI: 65.88%-68.76%), while the figures for physical inactivity were 32.68% (95% CI: 31.24-34.12%). The weighted proportion of males who were physically inactive was 31.96% (95% CI: 29.69%-34.23%). The weighted proportion of females who were physically inactive was 33.13% (95% CI: 31.27-34.99%) The difference was not statistically significant (p = 0.437). According to residence, 44.73% (95% CI: 43.27%-46.19%) urban residents were physically inactive. The corresponding figure for rural residents was 27.51% (95% CI: 25.56%-29.47%). The difference was statistically significant (p < 0.001). The weighted prevalence of inactivity for participants aged 40 years and below was 31.41% (95% CI: 29.50%-33.32%), the corresponding figure for those aged above 40 years was 34.61% (95% CI: 32.37%-36.84%). The difference was statistically significant (P = 0.033).

5.2.9. Predictors of being physically active

Binary logistic regression showed that age and place of residence (urban versus rural) had a significant association with physical activity. Urban dwellers were less likely to be physically active compared to rural dwellers (AOR = 0.477; 95% CI = 0.410-0.555). For each year increase in age, the odds of being physically active decreases by a factor of 0.993 (AOR = 0.993; 95% CI= 0.988-0.998). Gender, income level and education did not predict the likelihood of being physically active or not (Table 5.9).

Table 5.9. Predictors of Physical Activity (binary logistic regression)

Predictor	AOR	95% confidence interval		p-value
		Lower	Upper	
Age	0.993*	0.988	0.998	0.008
Male gender	0.979	0.864	1.109	0.735
Urban residence	0.477*	0.410	0.555	< 0.001
Income-class[a]				0.061
Low-income class	1.164	0.930	1.458	0.184
Middle-income class	0.914	0.729	1.146	0.436
Years of education	1.020	1.000	1.040	0.050
Constant	2.547			0.000

a reference category: upper-income class

* significant i.e p < 0.05

Abbreviations: AOR = Adjusted Odds Ratio

5.2.10. Physical inactivity and obesity/overweight

The weighted proportion of inactive persons who were obese was 7.89% (95% CI: 6.39%-9.39%), while the proportion of active persons who were obese was 6.16% (95% C: 5.30%-7.02%) The difference was statistically significant, $p < 0.006$. The weighted proportion of inactive persons who were overweight (20.69%; 95% CI: 18.35%-23.04%) was significantly higher than that of active persons who were overweight (18.35%; 95% CI: 16.93%-19.77%), $p = 0.018$. Physical inactivity had a significant impact on obesity and overweight in the best model after controlling for gender and age. Physical inactivity significantly increases the odds of being obese by a factor of 1.428 (AOR: 1.428; 95% CI: 1.190-1.714). Similarly, physical inactivity significantly increases the odds of being overweight by a factor of 1.231 (AOR: 1.231; 95% CI: 1.089-1.391). These are shown in Table 5.10

Table 5.10. Effect of physical inactivity on obesity and overweight (multinomial regression)

BMI category [a]	Variable	AOR	95% Confidence Interval		p-value
			Lower	Upper	
Obese	Intercept				< 0.001
	Physically inactive	1.428*	1.190	1.714	< 0.001
	Physically active [b]	.	.	.	.
	Male gender	0.318*	0.257	0.393	< 0.001
	Female gender [b]	.	.	.	.
	Urban residence	2.421*	1.927	3.043	< 0.001
	Rural residence [b]	.	.	.	.
	≤ 40 years of age	0.343*	0.285	0.413	< 0.001
	> 40 years of age [b]	.	.	.	.
Overweight	Intercept				< 0.001
	Physically inactive	1.231*	1.089	1.391	0.001
	Physically active [b]	.	.	.	.
	Male gender	0.762*	0.674	0.860	< 0.001
	Female gender [b]	.	.	.	.
	Urban residence	1.724*	1.494	1.988	< 0.001
	Rural residence [b]	.	.	.	.
	≤ 40 years of age	0.725*	0.638	0.825	< 0.001
	> 40 years of age [b]	.	.	.	.

Underweight	Intercept				< 0.001
	Physically inactive	1.022	0.829	1.261	0.837
	Physically active [b]	.	.	.	.
	Male gender	1.186	0.973	1.447	0.092
	Female gender [b]	.	.	.	.
	Urban residence	0.517*	0.420	0.635	< 0.001
	Rural residence [b]	.	.	.	.
	≤ 40 years of age	0.900	0.728	1.112	0.327
	> 40 years of age [b]	.	.	.	.

a = reference category for BMI class is: normal weight.

b = reference category for predictor variable

* = significant (i.e p < 0.05)

5.2.11. Outdoor leisure time physical exercise

Only 6.45% (95%CI: 5.82%-7.09%) participants reported at least once a week outdoor leisure time physical exercises while 93.55% (95% CI: 92.91%-94.18%) did not. The weighted proportions of males and females who reported at least once a week outdoor leisure time physical exercises were 7.42% (95%CI: 6.37%-8.46%) and 5.73% (95% CI: 4.94%-6.53%) respectively. The difference was statistically significant (P= 0.012). Only 3.46% (95% CI: 2.66%-4.26%) rural dwellers reported at least once a week outdoor leisure time physical exercise. The corresponding figure for urban dwellers was 13.44% (95% CI: 12.46%-14.43%). The difference was statistically significant (P< 0.001). Only 7.04% (95% CI: 6.13%-7.95%) persons below the age of 40 years and 5.53% (95% CI: 4.62%-6.44%) persons above the age of 40 years engage in outdoor leisure time physical exercise at least once a week. The difference was statistically significant (P= 0.0.02).

5.2.12. Predictors of outdoor leisure time physical exercise

Binary logistic regression analysis showed that individuals aged 40 years and below are about 1.4 times more likely to engage in outdoor leisure time physical exercise than those aged above 40 years (AOR=1.367; 95% CI=1.095-1.707). Males were more likely to engage in outdoor leisure time physical exercise than females. However, this did not reach statistical significance (AOR =

1.225; 95% CI = 0.991-1.514). Urban dwellers are nearly three times more likely to engage in in outdoor leisure time physical exercise compared to rural dwellers (AOR = 2.989; 95% CI = 2.114-4.227). Compared to the high-income class, the low-income class are less likely to engage in outdoor leisure time physical exercise (AOR= 0.536; 95% CI=0.371-0.782). Similarly, those in middle-income class are less likely to do outdoor leisure time physical exercise compared to the high-income class (AOR=0.535; 95% CI=0.394-0.727). Having university education increases the likelihood of outdoor leisure time physical exercise by three times (AOR=3.107; 95% CI= 2.237-4.315). Table 5.11 summarises the outcome of the binary logistic regression analysis on predictors of outdoor leisure time physical exercise.

Table 5.11. Predictors of outdoor leisure-time physical exercise (binary logistic regression)

Predictor	AOR	95% confidence interval		p-value
		Lower	Upper	
≤ 40 years of age	1.367*	1.095	1.707	0.006
Male gender	1.225	0.991	1.514	0.061
Urban residence	2.989*	2.114	4.227	< 0.001
Income-class [a]				
Low-income class	0.536*	0.367	0.782	0.001
Middle-income class	0.535*	0.394	0.727	< 0.001
University education	3.107*	2.237	4.315	< 0.001

[a] reference category for income class = high-income class

* significant (p<0.05)

5.2.13. Hindrances to outdoor leisure time physical exercise

Amongst urban dwellers, 1183 (25.6%) respondents did not give any reason, 846 (18.3%) reported lack of time while 468 (10.1%) reported fear of criminals as their most important reason for not engaging in outdoor leisure time physical exercises. The corresponding figures among the rural residents were 705 (35.5%), 582 (29,1%) and 23 (1.2%) (Table 5.12).

Table 5.12. Hindrances to outdoor leisure time outdoor physical exercises in urban and rural areas

Hindrance	Urban residents N= 4630	Rural residents N= 1998	P-value
No reason	1183 (25.6%)	705 (35.3%)	<0.001
Not hindered	969 (20.9%)	127 (6.4%)	<0.001
Lack of time	846 (18.3%)	582 (29.1%)	<0.001
Fear of criminals	468 (10.1%)	23 (1.2%)	<0.001
Fear of traffic	391 (8.4%)	8 (0.4%)	<0.001
In-door exercise	373 (8.1%)	62 (3.1%)	<0.001
Lack of interest	345 (7.5%)	462 (23.1%)	<0.001
Disability	45 (1.0%)	24 (1.2%)	0.429
Ill-Health	10 (0.2%)	5 (0.3%)	1.000

5.2.14. Behavioural risk factors for obesity and overweight: dietary factors

The weighted proportion of obese persons who reported eating three or more full meals per day in the preceding 30 days (50.55%; 95% CI: 43.85%-57.25%) was similar to the proportion of non-obese persons who reported eating 3 or more full meals per day in the preceding 30 days (49.23%; 95% CI: 47.59%-50.88%), p =0.708. The weighted proportion of obese persons who reported taking carbonated drinks daily in the preceding 30 days (35.71 %; 95% CI: 29.71%-41.71%) was similar to the proportion of non-obese persons who reported taking carbonated drinks daily in the preceding 30 days (34.08. %; 95% CI: 32.63%-35.52%), p =0.604. For fruit intake, 45.53% (95% CI: 38.84%-52.21%) obese persons had no daily fruit intake in the preceding 30 days. The corresponding figure for non-obese persons was 45.57% (95% CI: 43.92%-47.21%). The difference was not statistically significant (p= 0.990). These are shown in Table 5.13

For overweight, 49.32% (95% CI: 45.46%-53.17%) overweight persons reported eating 3 or more full meals per day, while 49.35% (95% CI: 47.59%-51.11%) non-overweight persons reported same. The difference was not statistically significant (p= 0.988). For carbonated drinks, 33.69% (95% CI: 30.35%-37.04%) overweight persons reported taking carbonated drinks daily in the preceding 30 days. The corresponding figure for non-overweight persons was 34.27% (32.72%-35.81%). The difference was not statistically significant (p= 0.759). The weighted proportion of overweight persons who reported no daily fruit intake in the preceding 30 days (45.45%; 95% CI: 41.60%-49.30%) was similar to the proportion of non-overweight persons who reported no daily fruit intake in the preceding 30 days (45.55%; 95% CI: 43.80%-47.31%), p =0.962. These are shown in table 5.14.

In multinomial logistic regression, none of the dietary factors had a significant impact on the likelihood of obesity, after adjusting for age and gender in the best model. This is shown in table 5.15

Table 5.13. Comparison of weighted estimates of dietary factors between obese and non-obese (z-test)

Dietary variable	Obese (95% CI)	Non-obese (95% CI)	p-value
≥ 3 full meals per day	50.55% (43.85%-57.25%)	49.23% (47.59%-50.88%)	0.708
Carbonated drink intake	35.71% (29.71%-41.71%)	34.08% (32.63%-35.52%)	0.604
No fruit intake	45.53% (38.84%-52.21%)	45.57% (43.92%-47.21%)	0.990

Table 5.14. Comparison of weighted estimates of dietary factors between overweight and non-overweight (z-test)

Dietary variable	Overweight (95% CI)	Non-overweight (95% CI)	p-value
≥ 3 full meals per day	49.32% (45.46%-53.17%)	49.35% (47.59%-51.11%)	0.988
Carbonated drink intake	33.69% (30.35%-37.04%)	34.27% (32.72%-35.81%)	0.759
No fruit intake	45.45% (41.60%-49.30%)	45.55% (43.80%-47.31%)	0.962

Table 5.15. Dietary factors and obesity /overweight (multinomial regression)

BMI category [a]	Variable	AOR	95% Confidence Interval		p-value
			Lower	Upper	
Obese	< 3 full meals per day	0.981	0.819	1.175	0.835
	≥ 3 full meals per day	.	.	.	.
	No daily carbonated drinks	1.046	0.866	1.262	0.643
	Daily carbonated drinks intake	.	.	.	.
	No daily fruit intake	1.062	0.884	1.277	0.519
	No daily fruit intake	.	.	.	.
	≤ 40 years of age	0.341*	0.284	0.410	< 0.001
	> 40 years of age	.	.	.	.
	Male gender	0.318*	0.257	0.394	< 0.001
	Female gender	.	.	.	.
	Urban residence	2.603*	2.059	3.290	< 0.001
	Rural residence	.	.	.	.
Overweight	< 3 full meals per day	0.997	0.885	1.124	0.966
	≥ 3 full meals per day	.	.	.	.
	No daily carbonated drinks	1.050	0.927	1.191	0.443
	Daily carbonated drinks intake	.	.	.	.
	No daily fruit intake	1.075	0.951	1.215	0.249
	Daily fruit intake	.	.	.	.
	≤ 40 years of age	0.720*	0.633	0.819	< 0.001
	> 40 years of age	.	.	.	.
	Male gender	0.761*	0.673	0.860	< 0.001
	Female gender	.	.	.	.
	Urban residence	1.819*	1.570	2.108	< 0.001
	Rural residence	.	.	.	.

Underweight	< 3 full meals per day	0.924	0.757	1.127	0.437
	≥ 3 full meals per day	.	.	.	.
	No daily carbonated drinks	1.069	0.862	1.324	0.544
	Daily carbonated drinks intake	.	.	.	.
	No daily fruit intake	0.943	0.769	1.157	.576
	Daily fruit intake	.	.	.	.
	≤ 40 years of age	0.892	0.721	1.103	0.292
	> 40 years of age	.	.	.	.
	Male gender	1.179	0.966	1.440	0.105
	Female gender	.	.	.	.
	Urban residence	0.525*	0.423	0.651	< 0.001
	Rural residence	.	.	.	.

a: reference category is: Normal Weight.

* significant i.e. $p < 0.05$

5.2.15. Perceptions of large body size and obesity

The weighted proportions of respondents who had a negative view of large body size was 33.64% (95% CI: 32.14%-35.14%), 44.07% (95% CI: 42.48%-45.66%) respondents perceived large body size as a desirable positive attribute, while 22.29% (95% CI: 21.01%-23.58%) had a neutral view of large body size. Respondents who perceived large body size positively were one and half times as likely to be obese when compared with those who perceived large body size negatively (AOR: 1.448: 95% CI 1.093-1.919). Respondents who had a neutral perception of large body size were two and half times likely to be obese compared to those who perceived large body size negatively (AOR: 2.458; 95% CI: 1.878-3.217). This is shown in Table 5.16.

Table 5.16. Effect of positive perception of large body size on obesity (binary logistic regression)

Predictor	AOR	95% confidence interval		p-value
		Lower	Upper	
Positive perception of large body size [a]	1.448*	1.093	1.919	0.010
Neutral perception of large body size [a]	2.458*	1.878	3.217	< 0.001
Age in years	1.029*	1.019	1.038	< 0.001
Male gender	0.268*	0.210	0.343	< 0.001
Urban strata	1.682*	1.266	2.235	< 0.001
Low-income class [b]	0.513*	0.354	0.742	< 0.001
Middle-income class [b]	0.806	0.577	1.126	0.205
Years of education	1.037	0.998	1.077	0.064
Constant	0.025*			< 0.001

a: reference is negative perception of large body size

b: reference category is upper-income class

* significant i.e. $p < 0.05$

5.2.16. Perception of own body size and obesity

Only 49.16% (95% CI: 47.57%-50.76%) respondents correctly perceived their body size while 50.84% (95% CI: 49.24%-52.43%) misperceived their body size. Figure 5.6 illustrates how individuals within each BMI category perceive their body sizes. There was a minimal agreement between measured BMI and perceived own body size [Kappa coefficient: 0.11, SE 0.008, P = 0.0001].

About 7.75% (95% CI: 4.09%-11.41%) obese respondents perceived their weight to be underweight while 42.03% (95% CI: 35.52%-48.55%) obese persons perceived their weight to be normal weight as shown in Figure 5.7.

The proportion of the population who are taking actions to lose weight is 7.89% (95% CI: 7.09%-8.68%) while 34.49% (95% CI: 32.95%-36.04%) are taking actions to gain weight. Figure 5.8 illustrates the weight management behaviour of the population. Perception of own body size was a significant predictor of weight management behaviour. Respondents who misperceived their own body size as underweight were less likely to take actions towards losing weight than those who correctly perceive themselves to be obese/overweight (AOR: 0.050; 95% CI: 0.035-0.070). Similarly, respondents who misperceived their own body size as normal were also less likely to engage in weight losing behaviours than those who rightly perceived themselves as obese/overweight (AOR: 0.019; 95% CI: 0.014-0.026). This is shown in Table 5.17.

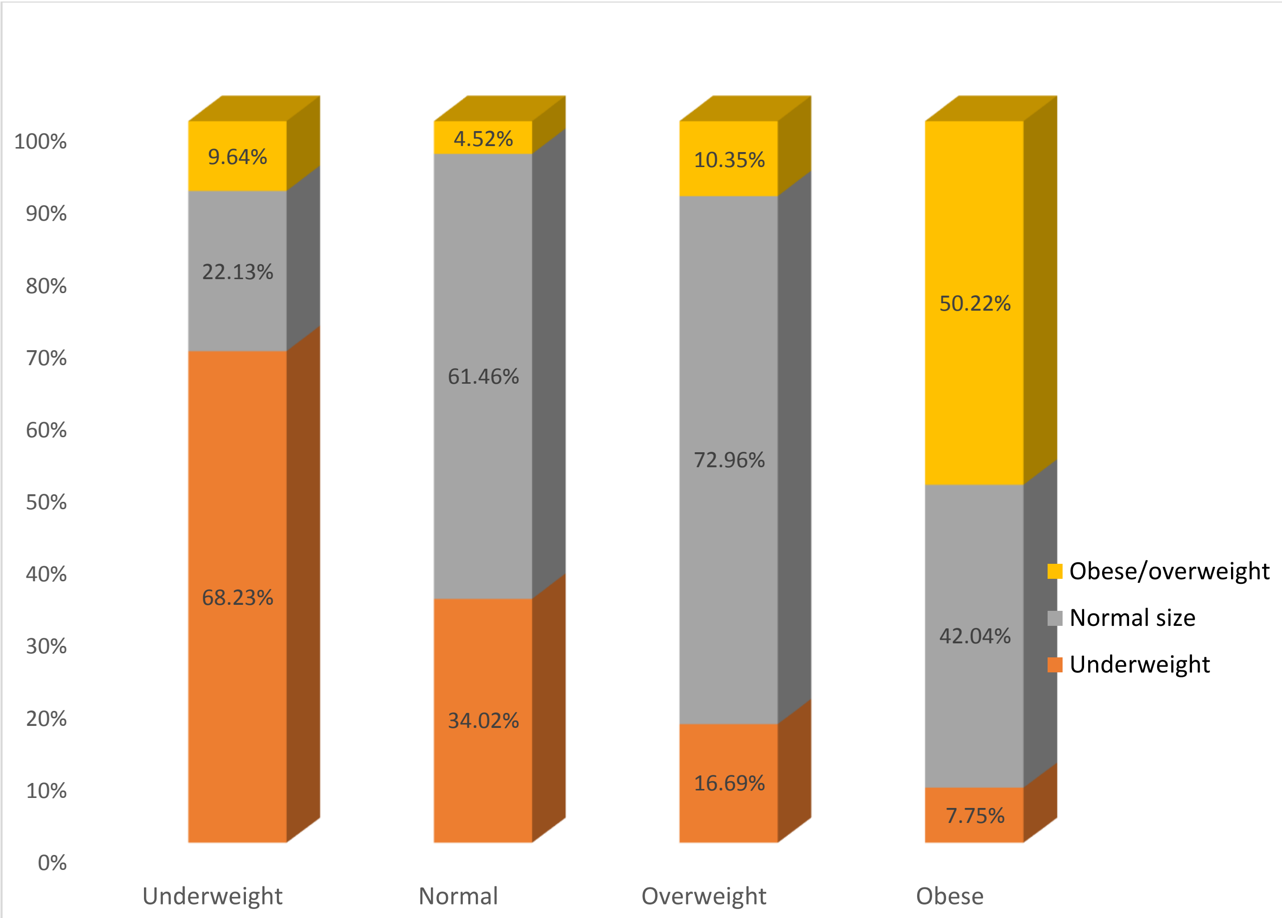


Figure 5.6. How individuals within each BMI category perceive their body sizes (weighted proportions)

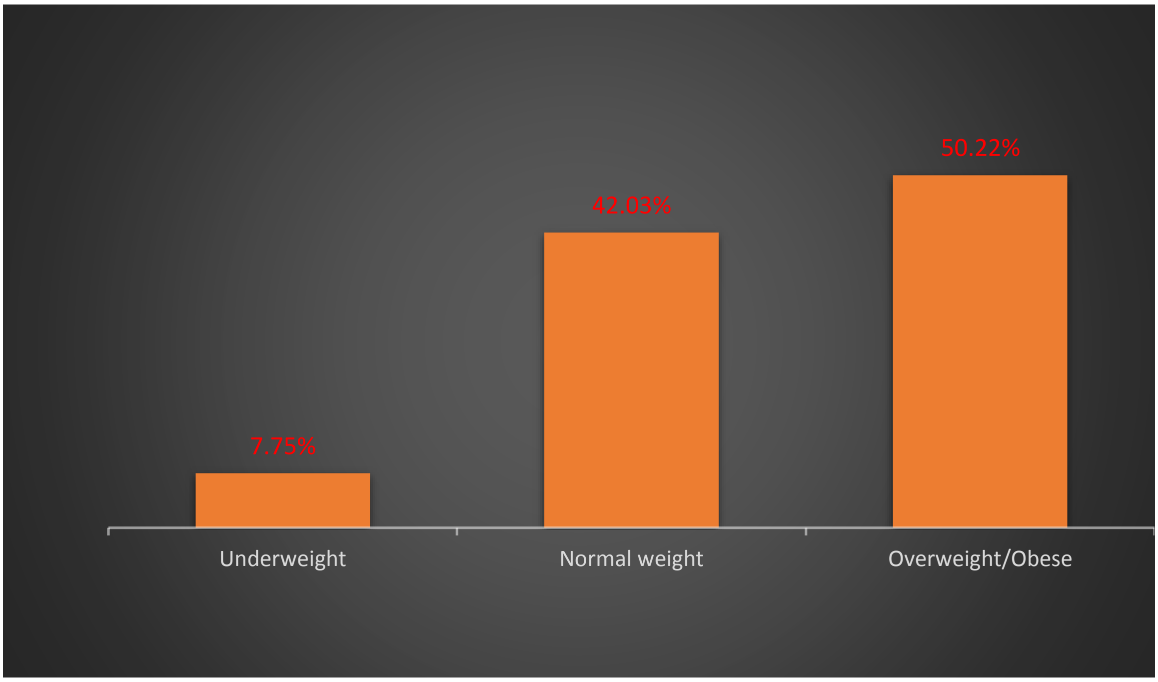


Figure 5.7. **How obese persons perceive their own body size (proportions are weighted)**

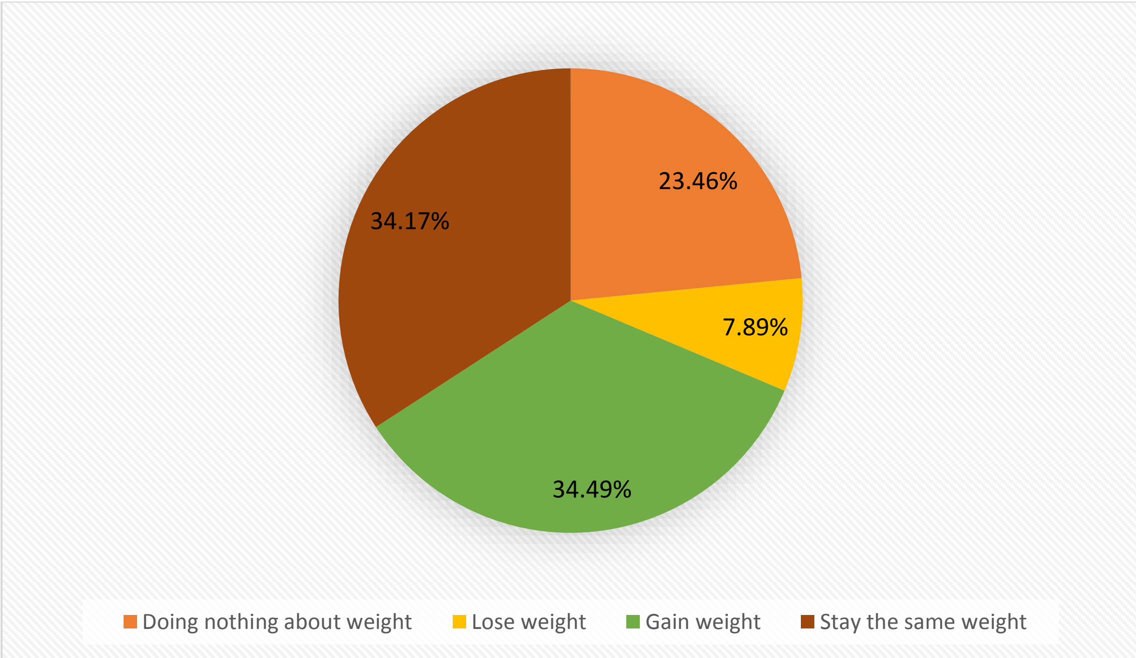


Figure 5.8. **Weight management behaviour of respondents (Weighted proportions)**

Table 5.17. Effect of perception of own body size on weight management behaviour (multinomial regression)

Weight management behaviour [a]	Variable	AOR	95% Confidence Interval		p-value
			Lower	Upper	
Lose weight	Perceived own body size as underweight	0.050*	0.035	0.070	< 0.001
	Perceived own body size as normal	0.019*	0.014	0.026	< 0.001
	Perceived own body size as obese/overweight	.	.	.	.
	≤ 40 years of age	1.111	0.893	1.384	0.345
	< 40 years of age	.	.	.	.
	Male gender	0.673*	0.543	0.835	< 0.001
	Female gender	.	.	.	.
	Urban residence	2.401*	1.859	3.100	< 0.001
	Rural residence	.	.	.	.
Gain weight	Perceived own body size as underweight	7.292*	4.792	11.096	< 0.001
	Perceived own body size as normal	0.538*	0.356	0.814	0.003
	Perceived own body size as obese/overweight	.	.	.	.
	≤ 40 years of age	1.041	0.893	1.215	0.606
	< 40 years of age	.	.	.	.
	Male gender	1.342*	1.160	1.551	< 0.001
	Female gender	.	.	.	.
	Urban residence	0.551*	0.473	0.643	< 0.001
	Rural residence	.	.	.	.
Doing nothing about weight	Perceived own body size as underweight	0.323*	0.233	0.448	< 0.001

	Perceived own body size as normal	0.339*	0.254	0.454	< 0.001
	Perceived own body size as obese/overweight	.	.	.	.
	≤ 40 years of age	1.010	0.883	1.154	0.889
	< 40 years of age	.	.	.	.
	Male gender	0.840*	0.741	0.953	0.007
	Female gender	.	.	.	.
	Urban residence	1.863*	1.609	2.157	< 0.001
	Rural residence	.	.	.	.

[a] = reference category is stay same weight

* = significant i.e. $p < 0.05$

CHAPTER 6

6. Discussion

6.1. Prevalence of Obesity and overweight

The study provides robust data on the prevalence and sociodemographic risk factors of overweight and obesity in Enugu southeast Nigeria, with a 95% confidence interval width for the prevalence of obesity well below ±1 percentage points. To the best of our knowledge, this is the largest household survey on obesity and overweight to include both urban and rural population as well as adult males and females in any Nigerian region. The representative method of data collection and the use of weighted estimates in the analysis give a reliable real population estimate. The overall prevalence of overweight and obesity of 19.0% and 6.8% respectively are very close to the range reported previously from Nigeria. A recent systematic review reported a range of 20.3% to 35.5% for overweight and 8.1% to 22.2% for obesity [231]. In Europe, the prevalence of overweight in adults is 34.8% while that of obesity was 12.8% [232]. In the United States, the prevalence of adult obesity for the year 2015-2016 was 39.8% [233]. The prevalence of obesity in this study is still way below that of the United States, but a little above half of the prevalence in Europe. With an underweight rate of 9.1% in this study, Nigeria is apparently facing the double burden of undernutrition and overnutrition. The burden of obesity is fast approaching the burden of underweight, and this calls for concern for a country where obesity has hitherto not been a significant public health issue. Nigeria is yet to develop a national policy on obesity. The dearth of robust, reliable data on the burden of obesity and overweight might have been contributory to the inadequate attention, which obesity is receiving in Nigeria. This study will contribute to bridge the gap in obesity data availability and stimulate further robust data collection on a national level.

6.2. Waist Circumference and Obesity

Males have significantly higher waist circumference than females. This is similar to findings from an earlier published smaller study from an urban city in Nigeria [234]. The positive linear correlation between waist circumference and BMI observed in this study was also reported in previous studies from Nigeria [234, 235]. The sensitivity and specificity of WC in detecting an obese person is higher in females than males. This supports the findings of a systematic review of studies done in sub-Saharan Africa [236]. The cut-off points for WC of 102.75 cm for men and 85.35cm for women are higher than the recommended value based on Caucasian measurements of 94cm and 80 cm respectively [237]. A previous study in Nigeria recommended WC cut-off points for obesity of 96cm and 95 cm for males and females respectively [238].

6.3. Triceps skinfold thickness and obesity

Females have significantly higher mean triceps skinfold thickness than males. This agrees with a previous report from Nigeria[239]. Triceps skinfold thickness has a better correlation with body mass index in women than in men in this study. However, the sensitivity and specificity of triceps skinfold thickness in detecting obesity are higher in males than females. There appears to be no globally recommended cut-off value for triceps skinfold thickness for obesity. The implication is that the findings of this study will add to the building knowledge base on triceps skinfold thickness and obesity. Furthermore, it is interesting to note that triceps skinfold thickness has better sensitivity and specificity in detecting obesity in both the male and female participants. This is a crucial finding that could be explored further in future studies.

6.4. Sociodemographic determinants of obesity and overweight

The results show that urban residents have higher risks for overweight and much higher risks for obesity than rural residents in all the models. Earlier studies from Nigeria and some countries in West Africa reported similar findings [240-242]. The urban-rural difference in the burden of obesity prevalence is not significant in Europe [243], but significant in the United States. The prevalence of obesity is reported to be higher in rural areas in the United State [244]. Urban-rural difference in obesity is mediated through diet and physical activity. In Nigeria, obesogenic foods are usually imported, and therefore more expensive than local foods that are less obesogenic. High-income earners almost exclusively reside in the urban areas in Nigeria. This means that practically only the urban residents will have the financial capacity to purchase these expensive imported foods. Hence, the imported high-calorie foods are almost exclusively available in the urban areas. Urban dwellers are therefore more exposed to, more financially-empowered to, and more likely to consume these foods than the rural dwellers. Again, human commuting is more vehicular in the urban areas than in the rural areas; hence rural dwellers are more likely to walk more than urban dwellers. The rural dwellers mainly engage in non-mechanized farming requiring a good deal of physical strength. These assertions are supported by the findings in this study, which showed a significantly higher level of physical activity among the rural residents. All the foregoing assertions might have contributed to the lower burden of overweight and obesity in rural areas.

Females are four times more likely to be obese than males. This risk remained significant in both urban and rural sub-group analysis. Previous authors reported similar findings from Nigeria [119, 122, 128, 241, 245-247]. The gender distribution of the burden of obesity in this study is the opposite of that in high-income countries. In Europe, males are more obese than females [232], while in the United States no significant difference exists between men and women overall [233]. Previous authors attributed the higher prevalence of obesity in females in low-income countries to the fact that men are usually engaged in more strenuous jobs, and many women are housewives with no formal employment and less physical activities [248]. The socio-cultural desirability of large body size for women in this setting could also be an additional contributory factor. Also, females are 1.3 times more likely to be overweight than males in this study. Reports from previous studies from Nigeria are conflicting. Some reported a higher proportion of males than females being overweight [128, 241, 248-250], others reported a higher proportion of females than males [122, 245-247]. In Europe, reports have consistently indicated a higher prevalence of overweight in men than women [232].

The odds of overweight and obesity increase with increasing age in this study. This agrees with the findings from previous studies in Nigeria, Europe and the United States [128, 232, 233, 242, 245]. The impact of age on obesity could be explained by physical activity. It is known that younger adults are more physically active than older adults [251, 252], as is also the finding in this study
We could not show additional significant impact of education on the risk of overweight and obesity. This contrasts with the findings of previous studies from Nigeria [128, 242, 248]. In high-income countries, the prevalence of overweight and obesity decrease with increasing education[232].
The income level of the individual is a significant predictor of obesity in this study. The high-income class was 2.3 times more likely to be obese than the low-income class. Previous studies from Nigeria reported similar findings [119, 122, 242, 248]. In high-income countries, there is an inverse relationship between obesity and income-class [232].

The findings of this study bring to the fore the problem of overweight and obesity in a setting that is equally plagued with undernutrition. The problems of overweight and obesity are likely to be ignored if not documented in robust data. Ignoring the emerging obesity epidemic might be a huge error in the future as the country's health system might not be positioned to handle these issues effectively. The time for Nigeria to begin to evolve policies to prevent and halt the emerging epidemic of obesity and overweight is now. Data provided from this study is expected to assist health policymakers in this regard.

6.5. Behavioural risk factors for obesity and overweight: physical activity

The result revealed a prevalence of physical inactivity of 32.68%, which is quite high. The prevalence of physical inactivity reported by previous studies of specific restricted populations from Nigeria ranged from 31% to 41% [251, 253]. The reported prevalence of physical inactivity from other African countries ranged from 17.4% in Kenya [254] through 33% among black South African women [255] to 37.6% in Uganda [256]. In a study involving 28 countries in Europe, the prevalence of physical inactivity was reported as 28% [257]. A report from a global survey involving 122 nations put the global prevalence of physical inactivity at 31.1% [258]. The level of physical inactivity in this study is close to the global estimate. However, this level of physical inactivity in Nigeria is likely to increase rapidly and surpass the global estimate as the economy of Nigeria improves, and more individuals acquire cars for routine transportation on improved road networks. An improved economy will also reduce the level of physical activity from manual labour as the use of machines will increase. The World Health Organisation member states are working to reduce the prevalence of physical inactivity by 10% in the year 2025 [259]. Currently, Nigeria does not have any national policy on physical activity. The findings of this study bring to the fore the current huge burden of physical inactivity in Nigeria, and the potential escalated burden that the country must contend with in the future as her economy improves. It is time to begin to give physical activity the attention that it deserves in Nigeria.

Although gender did not have an independent significant impact on physical activity in this study, previous studies from various regions of the globe have reported higher proportions of physical inactivity in females than males [102, 251, 252, 256, 257]. Rural dwellers were more than twice as likely to be physically active as urban dwellers. This finding supports the finding of other previous research works in Nigeria and Europe [253, 257]. Reports from the United States show mixed results. Most studies reported more physical inactivity in rural dwellers than urban dwellers [260, 261]. However, a recent report from the United States National Health and Nutrition Examination Survey (NHANES) showed that although rural dwellers are less active in high-intensity physical activity, total physical activity is more amongst rural dwellers than urban dwellers [262]. Urban/rural effects on physical activity are mediated through socioeconomic status and built physical environment. Physical activity tends to be higher in neighbourhoods with higher walkability. In Nigeria, rural residents are usually poor and only very few could afford personal cars. Furthermore, the rural roads are typically bad and hardly motorable, making vehicular transportation more challenging in rural areas. This means that rural dwellers are compelled to walk more than urban residents where the roads are better and the residents richer. This is a significant finding as government policies on physical activity must factor in these variables. Another correlate of physical activity from this study is age. As the age increases, the odds of meeting the approved level of physical activity reduces. This is similar to findings by previous researchers on the subject matter from Nigeria, Europe and South America [251, 252, 263, 264]. The proportions of physically inactive persons who are obese and overweight are significantly higher than the proportion of physically active persons who are obese and overweight. Physical inactivity also increases the odds of being obese and overweight by a factor of 1.4 and 1.2 respectively, and these impacts are significant. Physical inactivity is a known risk factor for obesity.

Outdoor leisure-time physical exercise is another essential component of physical activity. Only 6.45% of the population in this study reported at least once a week outdoor leisure-time physical exercise. This is quite low and demands actions that will encourage more people to be involved in leisure-time outdoor physical exercise. Urban dwellers are about three times more likely to engage in outdoor leisure-time physical exercise than rural dwellers, and individuals with university education are three times more likely to engage in outdoor leisure-time physical exercise than those without university education. This is quite understandable as education increases the awareness and appreciation of the importance of leisure-time physical exercise. More people with university education reside in the urban areas. The urban areas in Enugu have few recreational parks for leisure-time physical exercise while the rural areas have none. Furthermore, urban residents do less manual work, and less physical activity as shown in this study; hence may find outdoor leisure time physical exercise more desirable than rural residents who do more manual work and more physical activity. These are the likely factors that could explain the urban-rural difference in outdoor leisure-time physical exercise. Being in the high-income class and age 40 years and below are significantly associated with increased outdoor leisure-time physical exercise. These are similar to the situation in Europe [265].

The hindrances to outdoor leisure-time physical exercise are noteworthy. A large proportion (46.5% of urban residents and 41.7% of rural residents) of respondents had no reason or were not hindered from outdoor leisure-time physical exercise by any factor or were hindered by lack of interest in outdoor leisure-time physical exercise. This is an important observation. Appropriate promotional policies on outdoor leisure-time physical exercise have the potential of driving a positive behaviour change on this subset of the population. It is interesting to note that the fear of criminals (10.1% for urban and 1.2% for rural residents) and fear of traffic (8.4% for urban and 0.4% for rural residents) were not major hindrances to outdoor leisure-time physical exercise. Fear of crime and traffic were listed by WHO as barriers to physical exercise [259]. In Europe and North America, day length and weather conditions are reported as important barriers to outdoor physical exercise [266, 267]. A significantly higher proportion of rural dwellers reported lack of time and lack of interest as hindrances to outdoor leisure-time physical exercise than urban dwellers while more urban dwellers report fear of criminals, fear of traffic and in-door exercises than rural dwellers. These findings may be found useful in physical activity policy formulation.

6.6. Behavioural risk factors for obesity and overweight: dietary factors

The results showed that the proportions of obese and overweight persons who reported eating three or more full meals per day did not differ from those of non-obese and non-overweight persons who reported the same number of meals per day respectively. The same observation goes for carbonated sweet drinks and fruit intake. Carbonated sugary drinks have high sugar content and this impacts on obesity [83].

6.7. Perceptions of body size and its relationship with obesity and weight management behaviour

Nearly half of the respondents (44.07%) view obesity as a positive, desirable attribute. A recent report from Northern Nigeria indicated that 15.5% of participants considered obesity socially desirable and as a sign of good living and affluence [268]. Northern Nigeria is inhabited by the Hausa ethnic nationality while south-eastern Nigeria is home to the Igbo ethnic nationality. There are no previous studies on how the Igbo people, a nationality of more than 30 million persons, perceive obese body sizes; hence the findings from this study represent the first report. In another recent study from another African country, Kenya, more than one-third of men and women were reported to prefer large body sizes [269]. These findings suggest that obese body sizes might still be desired by a good proportion of the population in Africa. This is in stark contrast to the situation in Europe, North America, and Australia, where large body sizes are perceived negatively, and obese persons report social and work-related discriminations [270, 271]. This has implications for tackling the obesity epidemic. The positive socio-cultural perception of obesity in Nigeria and other settings in sub-Saharan Africa could be an important driving factor for the rising obesity prevalence in Africa despite the prevailing poverty and undernutrition. This study showed that positive perception of large body size has a positive association with obesity in this setting. Individuals who perceive obesity positively are 1.5 times more likely to be obese than individuals who perceive obesity negatively, after controlling for relevant confounders of age, gender, place of residence, economic class and education. The fact that this association remained as strong even after controlling for the important confounding factors highlights the potential contribution of veneration of large body size to obesity prevalence in a resource-constrained setting like Nigeria.

Perception of own body size is another important psychosocial aspect of the obesity discourse. The study showed very poor agreement between the self-perceived own body size and the measured body mass index of the individual. A similar poor agreement was reported from studies in Northern Nigeria and Europe [272, 273]. The study showed that more than half of the population (50.8%) misperceived their body size. Body size misperception reported in previous studies from Nigeria range between 26.7% to 53.6% [272, 274, 275]. In the United States, recent estimates of body size misperception fall between 9% and 55.9% [276-278]. A noteworthy finding in this study is how the obese population perceive their body sizes. Only one-half of obese persons perceive their body size correctly as obese or overweight, leaving out 49.78% of obese persons misperceiving their weight as either underweight or normal weight. This calls for national concern. There is an urgent need to map out intervention strategies to reverse these misperceptions. Obesity management strategies and policies are very unlikely to be effective in the face of such huge proportions of misperception among the obese. The phenomenon of obese persons misperceiving their size to be normal appears not be limited to low-income countries alone. Recent studies from the United States reported that as high as 71.4% of obese adults underestimate their body size [279]. Similarly, a report from a European country indicated that 91.7% of obese men and women underestimated their body size [273]. The difference between Nigeria and countries in Europe and North America is that while these nations recognize obesity as a national public health issue of importance and have national policies and strategies for obesity prevention and management; Nigeria is yet to recognize obesity and overweight as important issues that warrant public health interventions. Own body size perception can affect how people manage their weight. Less than 10% of the population are taking actions to lose weight while as much as 34.5% are making efforts to gain weight. It may be worthy to note that the prevalence of underweight is 9.1%, which is about one-quarter of the proportion of the population seeking to gain weight. Respondents who perceive their weight to be normal may be reluctant to engage in weight reduction activities and programmes.

The implication of the misperception is made evident in the finding that persons who perceive themselves as obese in this study are 20 times more likely to engage in weight losing behaviour than those who perceive themselves as having normal body size (Table 5.17). This supports the findings of studies from Europe and the United States where misperception of own body size has been found to influence weight management behaviours [280, 281]. From the intervention perspective, promotion of periodic self-weighing by individuals to provide objective and accurate assessment and perception of weight could be an important public health intervention to tackle the growing obesity epidemic.

6.8. Limitations of Study

The major limitation of this study is its cross-sectional design which has an inherent response bias and limited in its ability to make definitive cause and effect relationship. Since body size perception and body mass index were assessed same time, the associations observed in this study cannot be conclusively said to mean causality. It is also difficult to tell if the perceptions preceded the obesity or vice versa. There could also be recall bias, especially with the dietary data. Physical activity was not objectively measured in this study; hence data collected on physical activity was dependent on the recall ability of the respondents. However, a household population survey of this nature can only lend itself to a cross-sectional design as was done in this study.

6.9. Policy Implications of Results

The study shows important results that could positively affect public health policy development. The study provides an important evidence of a double burden of underweight and overweight/obesity in southeast Nigeria. It also provides comprehensive, robust and representative data on the prevalence and determinants of obesity and overweight in southeast Nigeria. It is expected that the findings of this study will stimulate the much-needed interest and discourse on obesity and overweight at the national level, and leading to the development of a comprehensive official policy on obesity and overweight in Nigeria. It is also expected that the study will stimulate further studies on the obesity and overweight.

CHAPTER 7

7. Conclusion

7.1. Conclusion

The weighted prevalence of obesity (6.8%) and overweight (19.0%) in Enugu southeast Nigeria are high. The prevalence of obesity is fast approaching that of underweight (9.1%). More than a quarter (25.8%) of the adult population is either obese or overweight. Age, gender, urban-rural residence, income class are predictive socio-demographic factors for obesity and overweight. Older adults (> 40 years of age), females, urban residents and the high-income earners have higher odds of obesity and overweight.

More than a third (44.07%) of the adult population in Enugu, southeast Nigeria, perceive large body size as a desirable positive attribute. Positive perception of large body size increases the odds of obesity. There is also a high level of misperception of own body size and this influences the weight management behaviour of affected individuals. Individuals who misperceive their body size to be normal or underweight have significantly increased odds of weight-gain behaviour.

The burden of physical inactivity (32.68%) in south-eastern Nigeria is high. Living in the urban areas, and increasing age are factors associated with an increase in physical inactivity. The level of outdoor leisure physical exercise is very low with only 6.45% of adults reporting at least once weekly outdoor leisure-time physical exercise. The major barriers include lack of time and lack of interest in outdoor leisure-time physical exercise. Living in urban areas, being less than 40 years of age, having a university education, and a high personal income are factors that positively drive outdoor leisure-time physical exercises.

There is a good relationship between BMI and WC in both males and females but much better in males. The cut-off point for WC for obesity is close to the recommended global value both males and females. The specificity and sensitivity of WC in predicting obesity are higher in males than females. A weak correlation was observed between TSKFT and BMI in both males and females but poorer in males. TSKFT was found to have higher sensitivity and specificity than WC in detecting obesity both in males and females.

7.2. Recommendations

A comprehensive official policy on obesity and overweight prevention and management is recommended in Nigeria. Policies and programmes that will promote awareness of the health benefits of physical activity and outdoor physical exercise are needed to help Nigeria achieve the global mandate of reducing physical inactivity by 10% in the year 2025. Public health education program on the dangers of obesity to health, promotion of self-weighing at home and positive weight management behaviours are also recommended. Periodic data collection on obesity and overweight to update and evaluate the obesity and overweight situation in Nigeria is recommended.

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Annex 1

Statement on Pre-release and Contributions

Three articles emanating from this study has been prepared for publication. The first article has already been accepted for publication and is undergoing the production process. The title of the accepted article

is "Prevalence and socio-demographic determinants of adult obesity: a large representative household survey in a resource-constrained African setting with double burden of under-nutrition and over-nutrition". The journal that accepted it for publication is the Journal of Epidemiology and Community Health.

The second article titled "Perception of body size and its association with obesity and weight management behaviour in Nigerian Population: a large state-wide representative study", has been submitted to Social Sciences and Medicine journal and it is currently undergoing revision.

The third article titled "Physical activity and outdoor leisure time physical exercise: a population study of correlates and hindrances in a resource-constrained African setting", is being reviewed for submission to Global Public Health journal.

The PhD candidate collected data with the help of trained data collectors and research assistants. The PhD candidate also did the data analysis, wrote all three articles for publication and wrote the PhD Thesis, all under the close supervision of all my supervisors.

Annex 2

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